Long-Term Moored Observations in the Stratus Deck Region of the Eastern Pacific: An Ocean Reference Station at 20°S, 85°W

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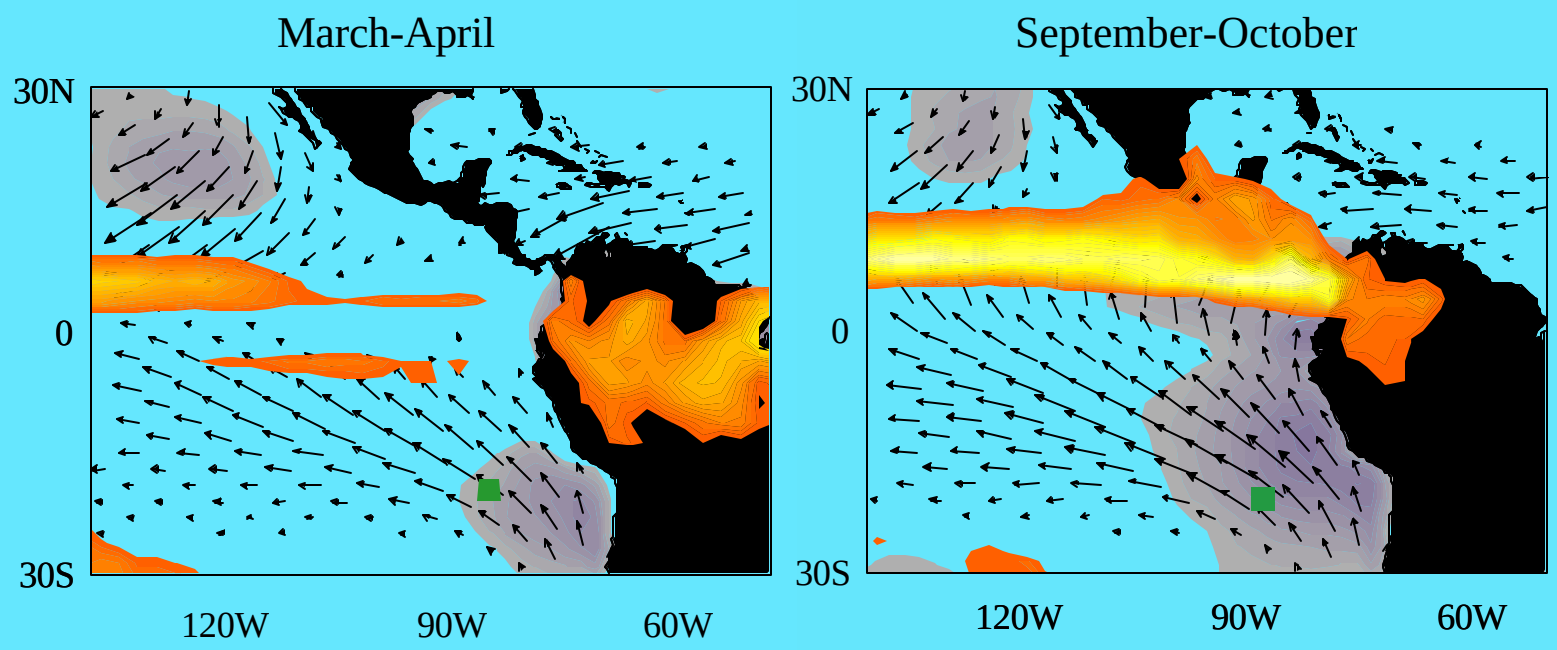


Ocean Reference Station under the Stratus Deck

- The maintenance of the mooring at 20°S, 85°W began under PACS and transitioned to the NOAA OGP Climate Observations Program. The overall objective is to maintain an Ocean Reference Station at this site which is of critical interest to climate research and observations. Long-term moorings are a key element of the ocean observing system as presented and confirmed at the Ocean Observations 99 Conference (Koblinsky and Smith, 2001).

Goals:

- **quantify atmosphere-ocean exchanges of heat, freshwater, and momentum on time scales from diurnal to decades,**
- **identify and correct errors in model and satellite-based surface meteorological and air-sea flux fields,**
- **motivate and verify improvement to atmospheric models,**
- **build on the above and to use the mooring as an anchor site for improved air-sea flux fields for the region,**
- **document the temporal evolution of the upper ocean on time scales from diurnal to decadal;**
- **provide the observational basis for identifying the physical processes that determine this evolution and set SST under the stratus clouds;**
- **provide the basis for examining the success of ocean and coupled models in this region;**
- **provide the data to examine how the upper ocean, surface meteorology, air-sea fluxes, and cloud cover co vary;**
- **provide the data needed to examine remote influences on the oceanographic, surface meteorological, and air-sea flux variability under the stratus deck.**

Surface mooring with 1-year turn-around starting October 2000

Meteorology: Wind spd and dir, air temp, SST, RH, BP, incoming SW and LW, precipitation. Two systems. Sampling: 1 minute

Ocean: Temperature, salinity, velocity in the upper 400 m, most above 250 m. Sampling: 7.5 to 60 minutes

Telemetry: Hourly surface met, not on GTS.

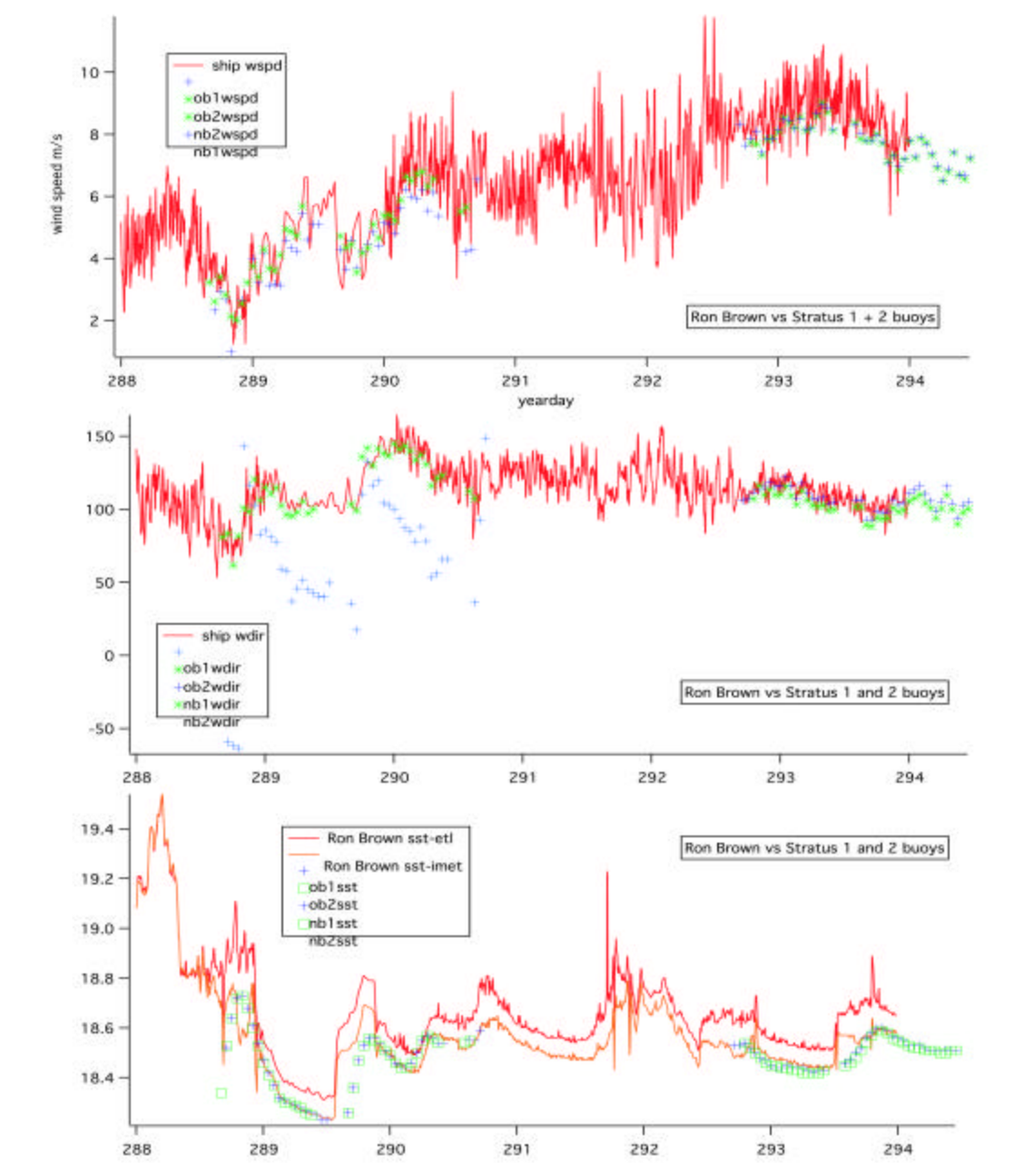
The mooring line is instrumented in the upper 300m to observe temperature, salinity, velocity. There is high vertical resolution over the mixed layer. This data is recorded internally. The mooring provides the first accurate and complete surface meteorological and air-sea flux time series and a matching record of upper ocean variability and thus anchors efforts to improve air-sea flux fields and model performance in the stratus region.

Observable	Units	Sampling Rate	Accuracy
Wind speed	$m\ s^{-1}$	1 minute	5%
Wind dir	degrees	1 minute	1.5°
SST	°C	1 minute	.1°C
T air	°C	1 minute	.1°C
Barometric Pressure	mb	1 minute	.5 mb
Precipitation	$mm\ hr^{-1}$	1 minute	.01 $mm\ hr^{-1}$
SW in	$W\ m^{-2}$	1 minute	3%
LW in	$W\ m^{-2}$	1 minute	10 $W\ m^{-2}$
Relative humidity	%	1 minute	3%
Latent heat	$W\ m^{-2}$	1 minute	5 $W\ m^{-2}$
Sensible heat	$W\ m^{-2}$	1 minute	2 $W\ m^{-2}$
SW net	$W\ m^{-2}$	1 minute	10 $W\ m^{-2}$
LW net	$W\ m^{-2}$	1 minute	5 $W\ m^{-2}$
Q net	$W\ m^{-2}$	1 minute	10 - 15 $W\ m^{-2}$
Wind stress	$N\ m^{-2}$	1 minute	.01 $N\ m^{-2}$
Ocean Temperature	°C	3.75 to 30 min	.01°C
Ocean Salinity	psu	3.75 minutes	.05 psu
Ocean Velocity	$cm\ s^{-1}$	7.5 to 30 min	1%

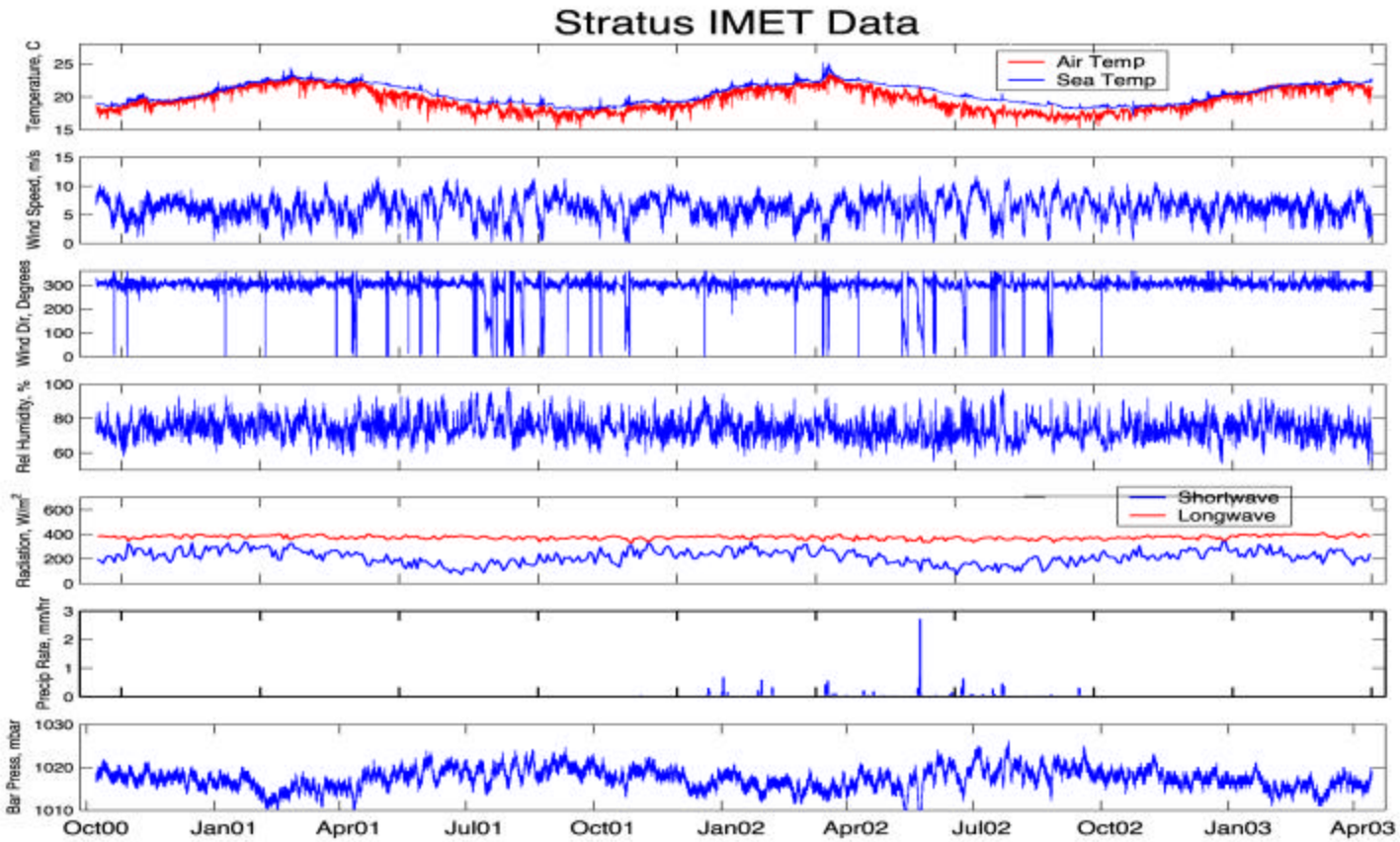
Accuracies of moored sensors - in the field

Extensive calibrations and intercomparisons

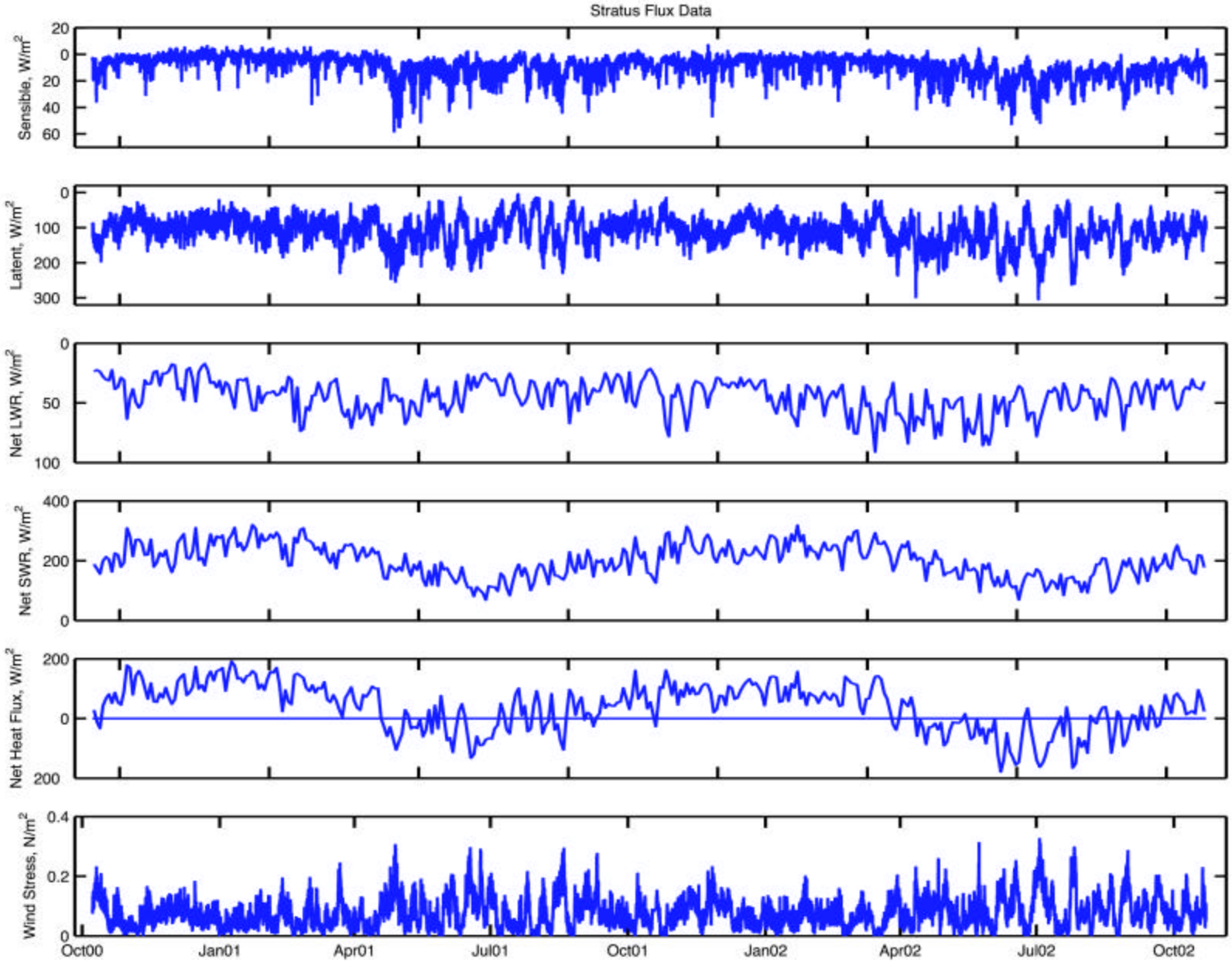
- calibrated prior to deployment;
- ‘burned in’ in the configuration they will be deployed, writing test records, prior to deployment, compared to standards;
- checked again after shipment, with buoy assembled prior to loading on the ship;
- once deployed, a dedicated buoy-ship comparison, using shipboard IMET sensors or those from C. Fairall, NOAA ETL
- at sea, data from the two independent IMET systems monitored and compared to NWP data at the nearest grid point;
- prior to recovery, after a year in the water, a dedicated ship buoy comparison repeated, with fresh buoy deployed nearby or on board;
- after recovery, sensors are inspected and, without cleaning, post-calibrated.



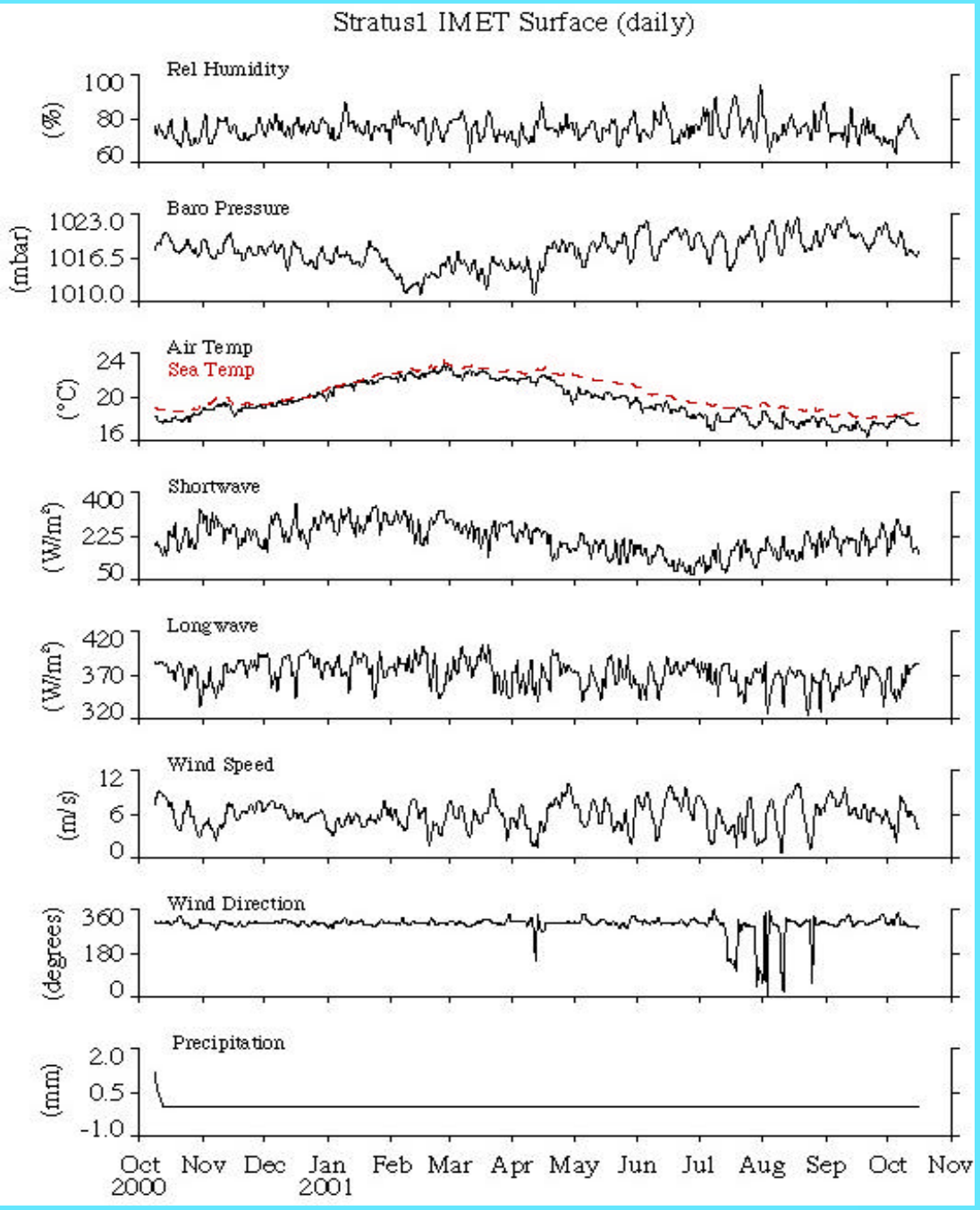
Ship-buoy comparisons play a vital role in establishing the accuracy of the moored observations. An example from EPIC 2001 when the Ron Brown was at the site for 6 days.



2.5 years of data, including telemetry since Oct 2002



Air-Sea Fluxes at Stratus Mooring, 20°S, 85°W
Oct 2000 to Oct 2002



First accurate in-situ surface meteorology time series under the stratus.

Year 1means:

u -4.5 v 3.4 m/s

wind dir 307° spd 6.1 m/s

air T 19.6°C, SST 20.4°C

RH 75.5% SH 10.5 g/kg

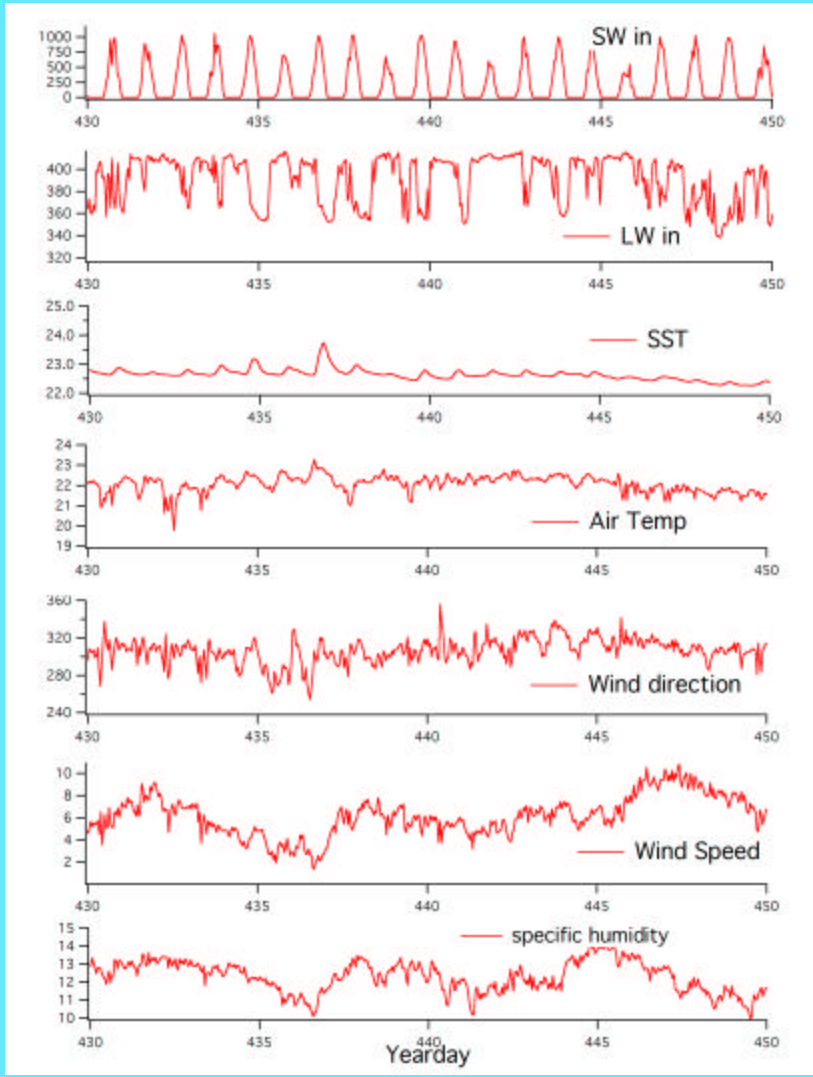
SW_{in} 213.9 Wm^{-2}

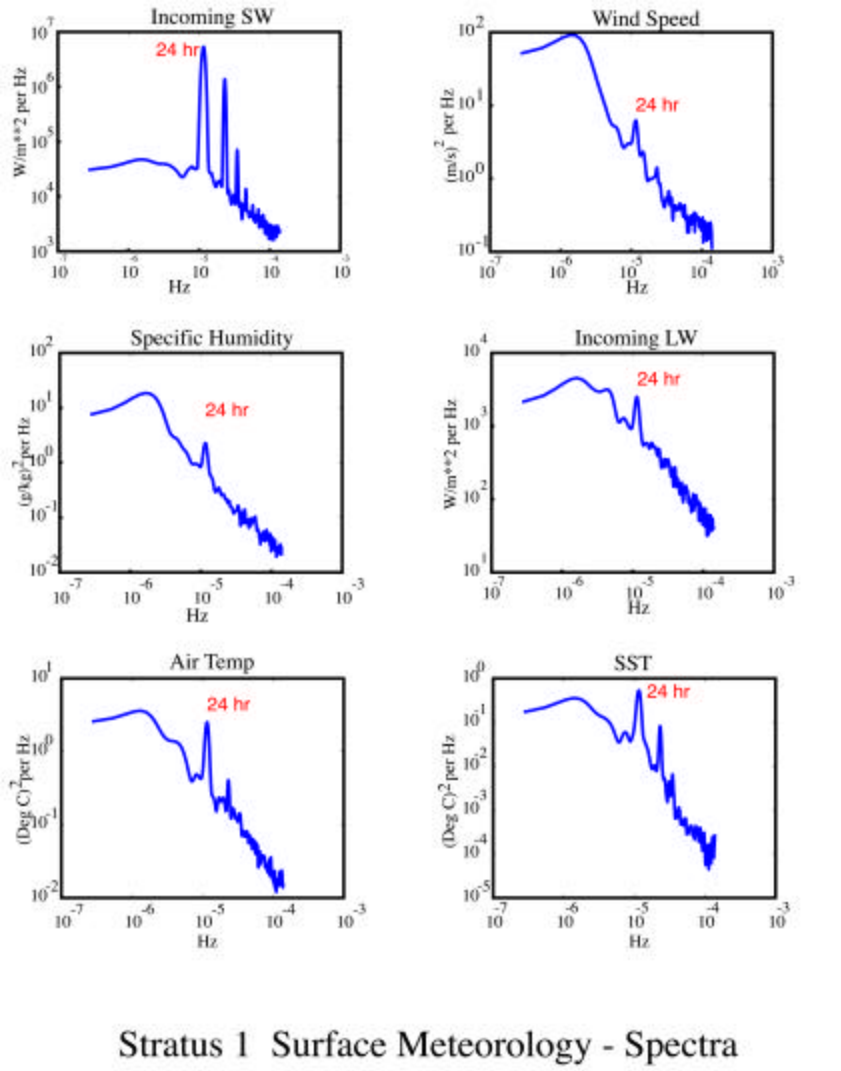
LW_{in} 378.4 Wm^{-2}

BP 1017.6 mb

Precip 0 mm yr^{-1}

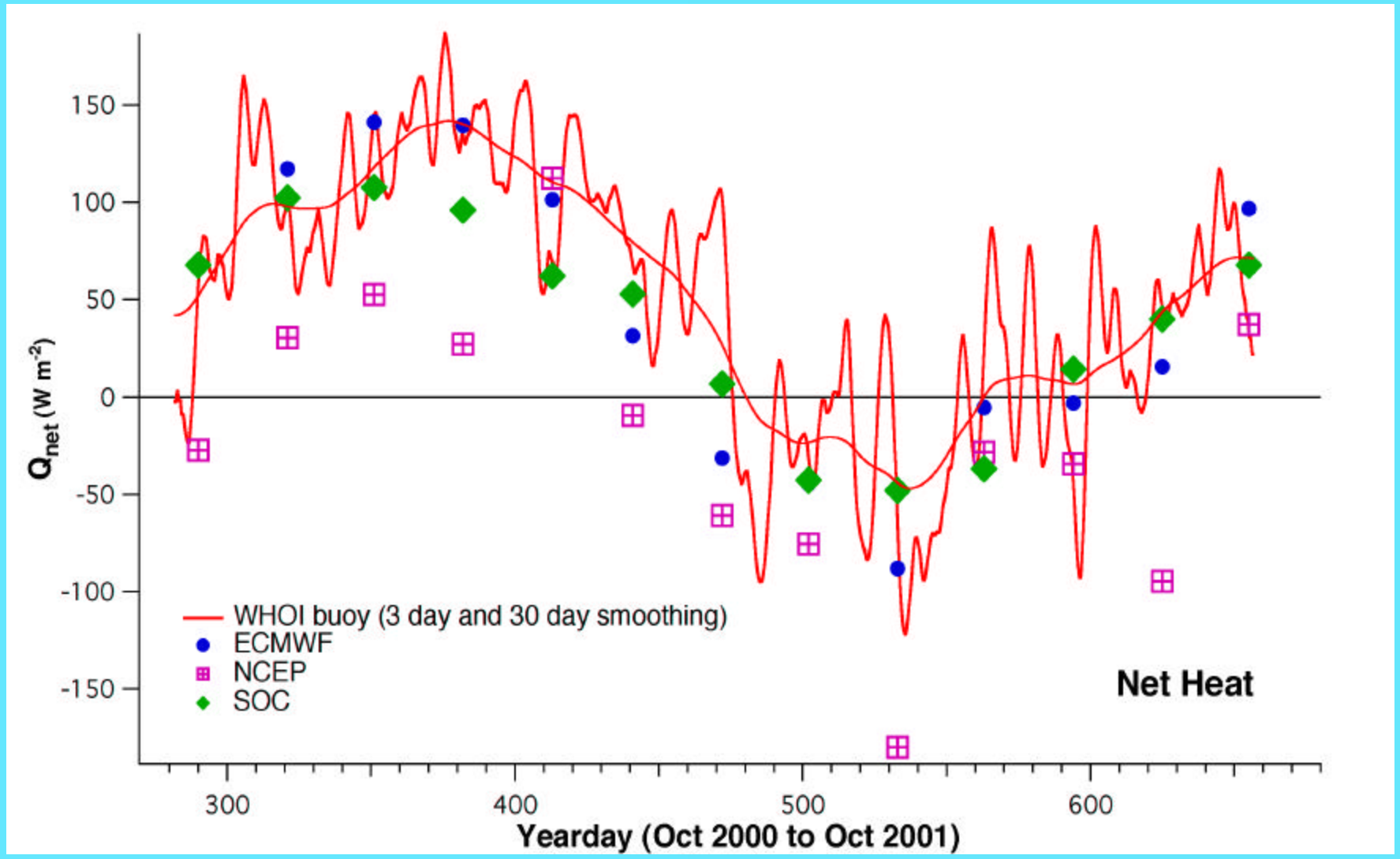
Surface meteorology under the stratus





Diurnal variability is strong - and there are even more rapid changes in surface meteorology, requiring high temporal resolution to get reliable statistics.

Surface fluxes at the mooring versus climatologies and models: large differences in NWP net heat flux compared to observed.

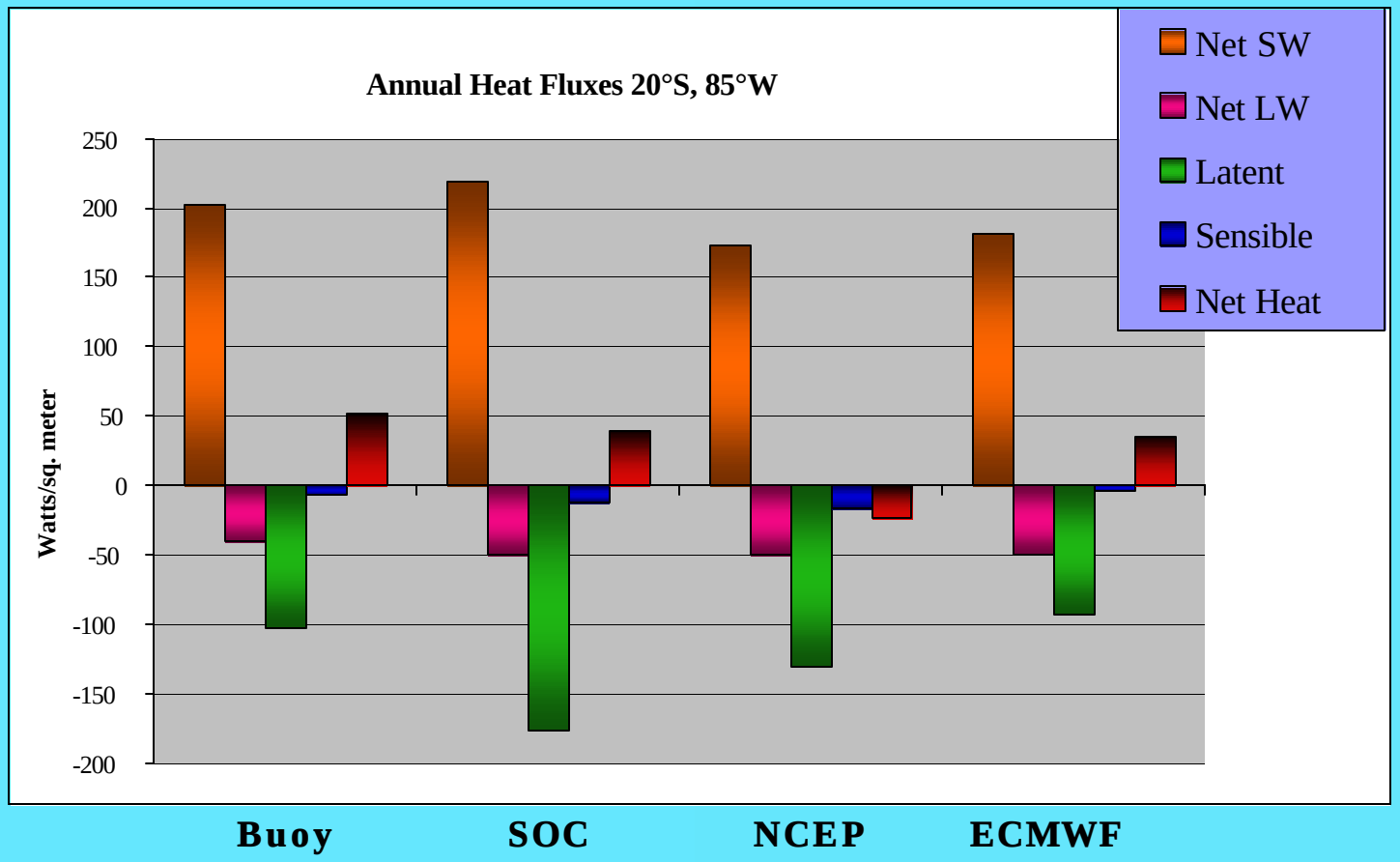


Annual fluxes: observed vs climatology

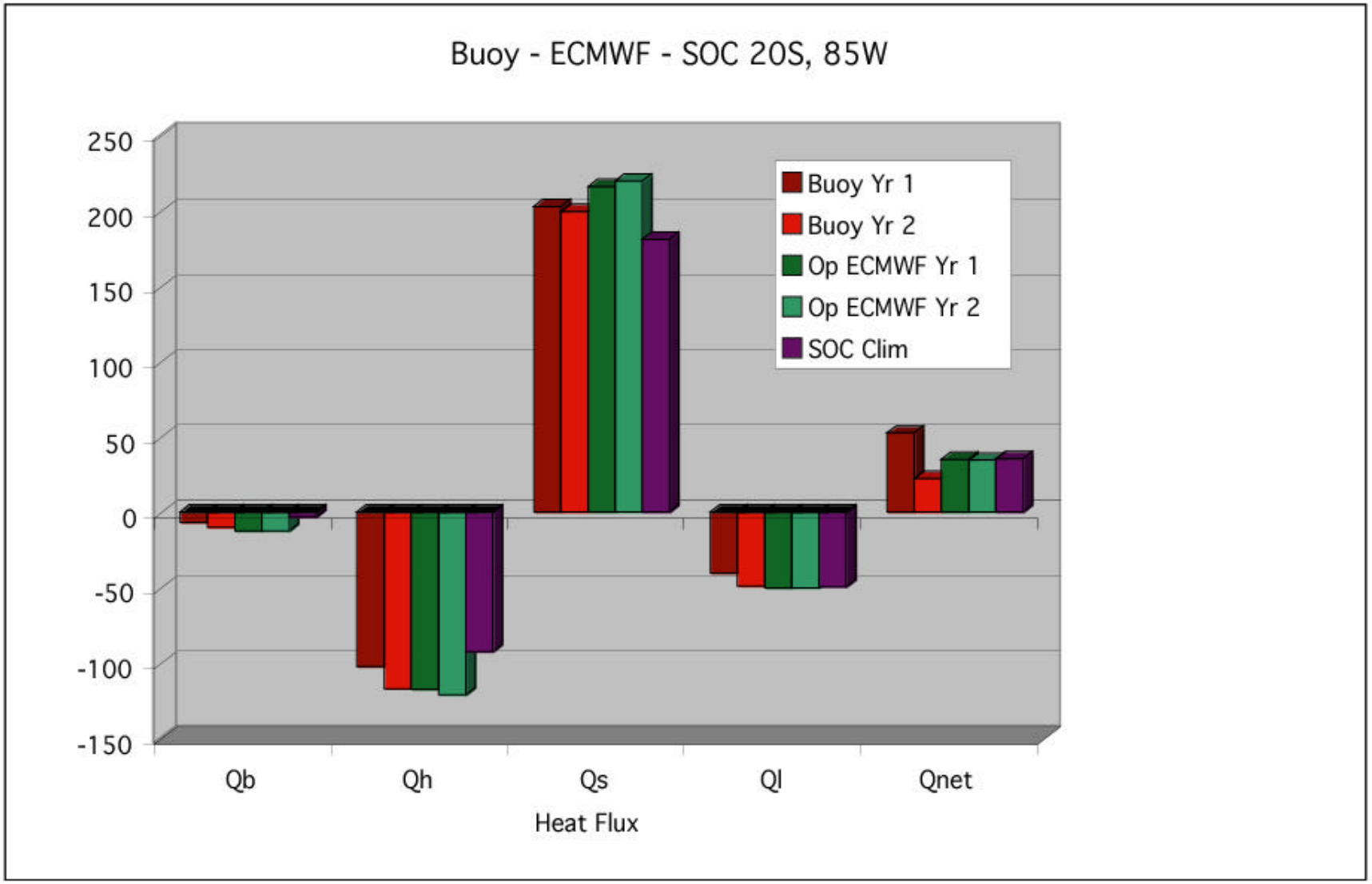
Annual net heat ranges from +52 to -24 W m^{-2}

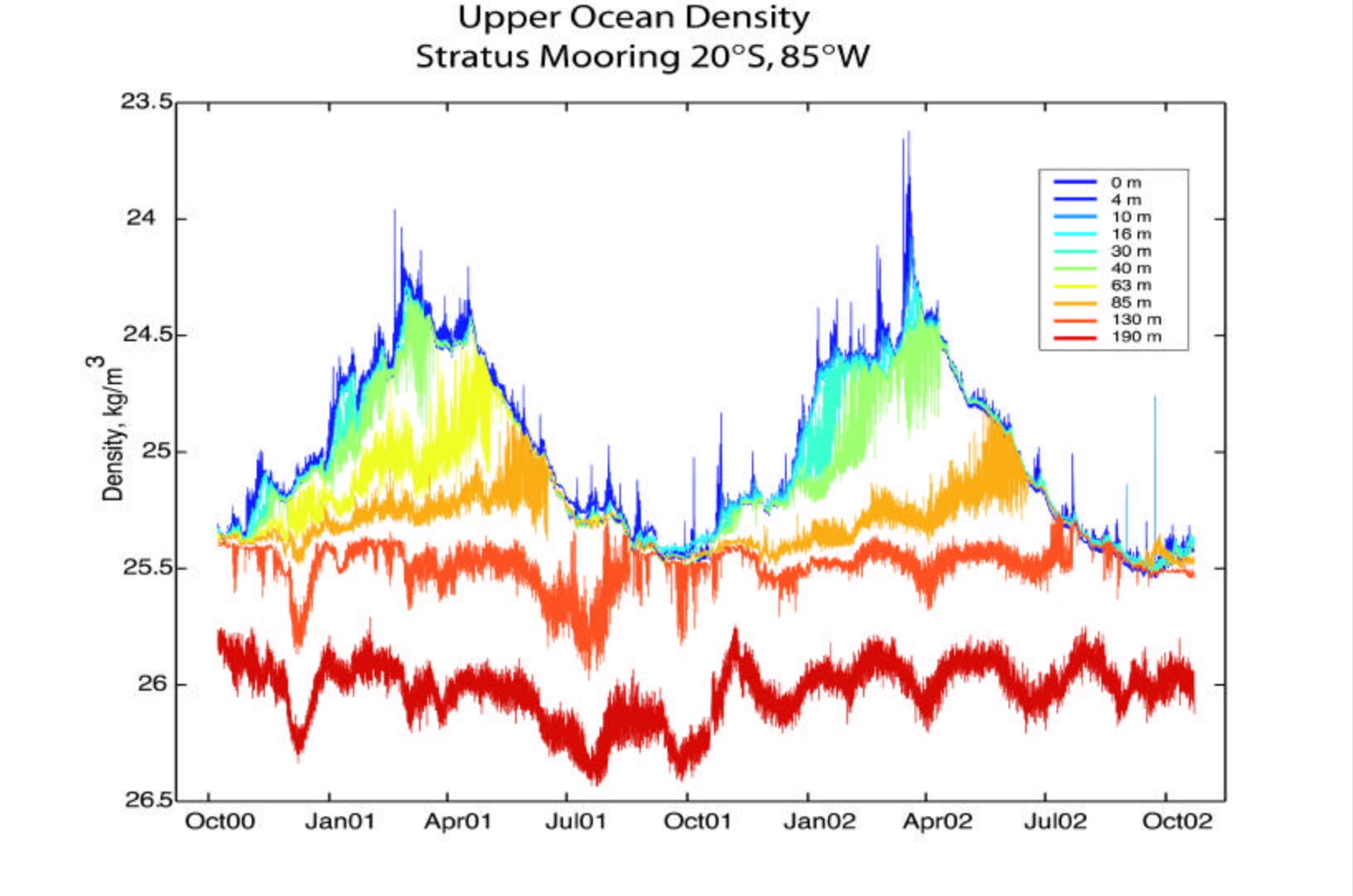
NCEP stress 30% stronger

Models: rain (.07 to .3 m yr^{-1}) Buoy: no rain



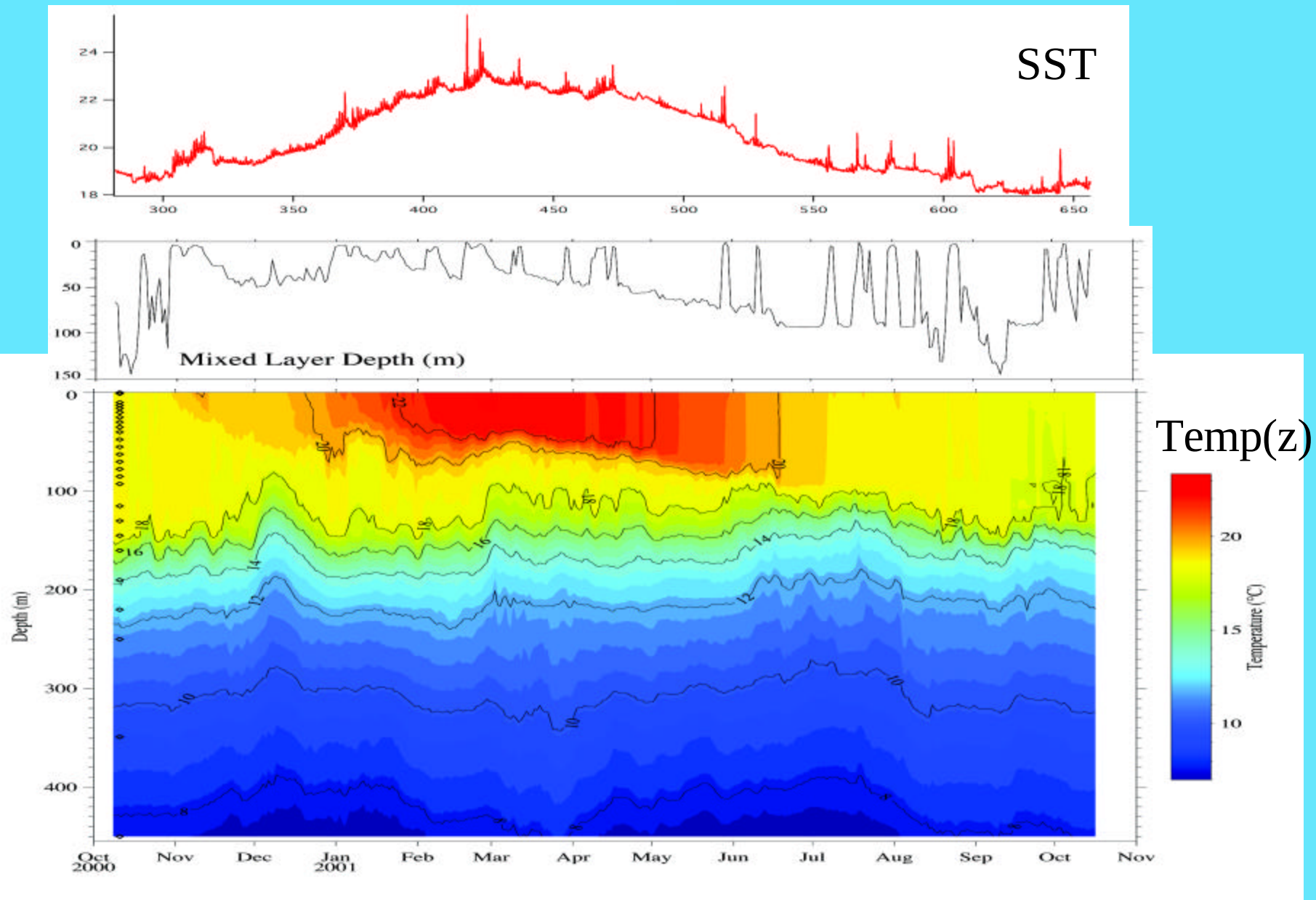
Buoy data shows year to year variability not replicated by ECMWF operational model



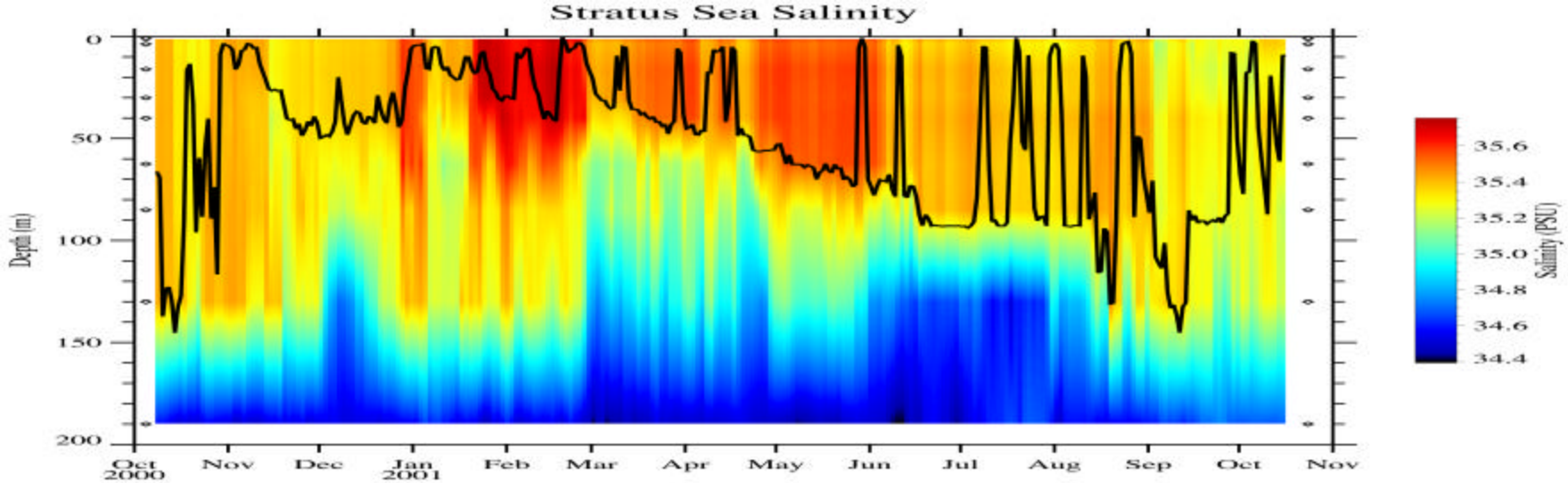


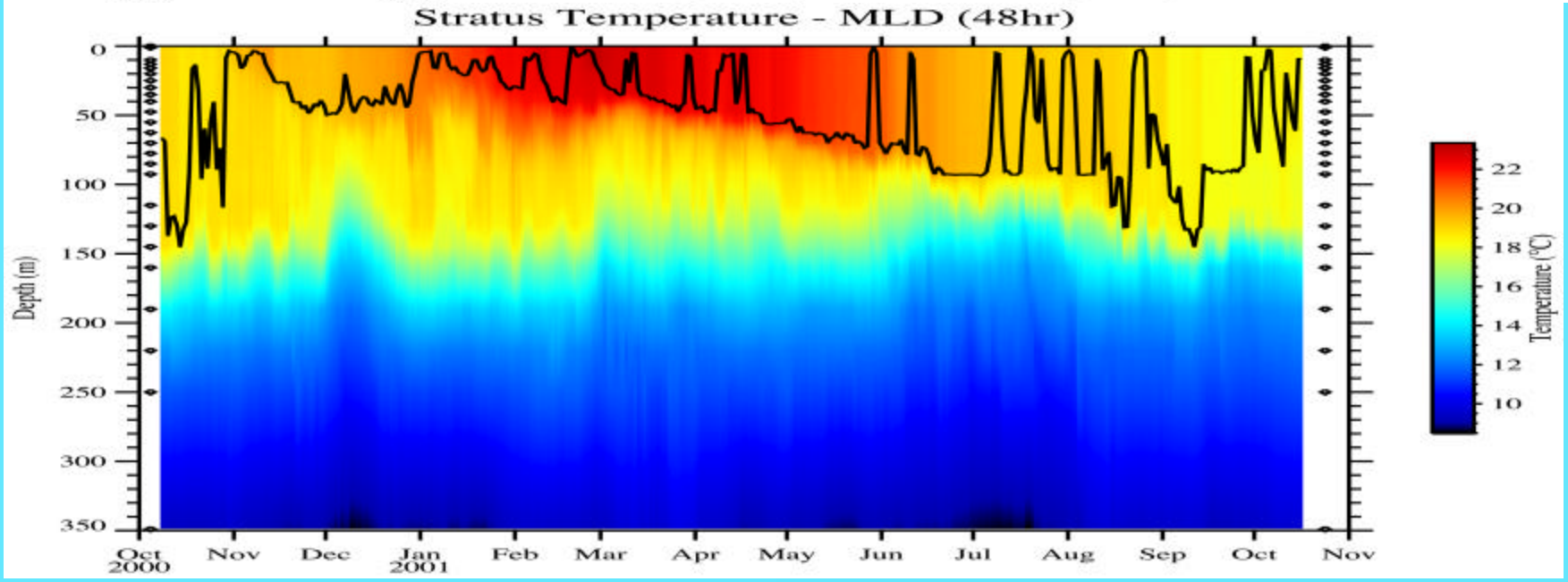
Strong diurnal warming events occur when trade winds die in strength. Thermocline shows eddy variability.

Upper ocean variability under the stratus deck

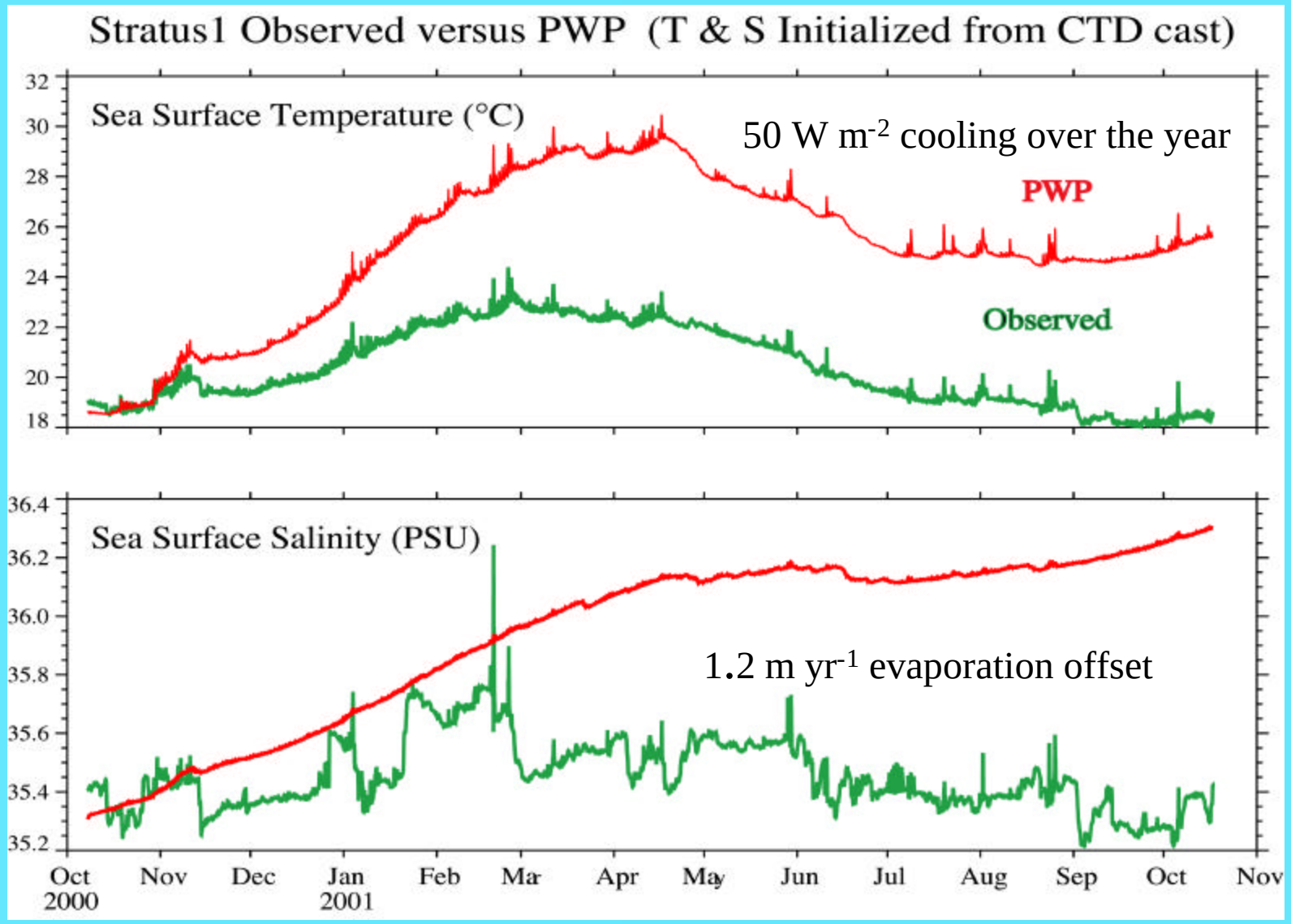


Upper ocean variability under the stratus deck; salinity and temperature. Net evaporation, net warming at sea surface.

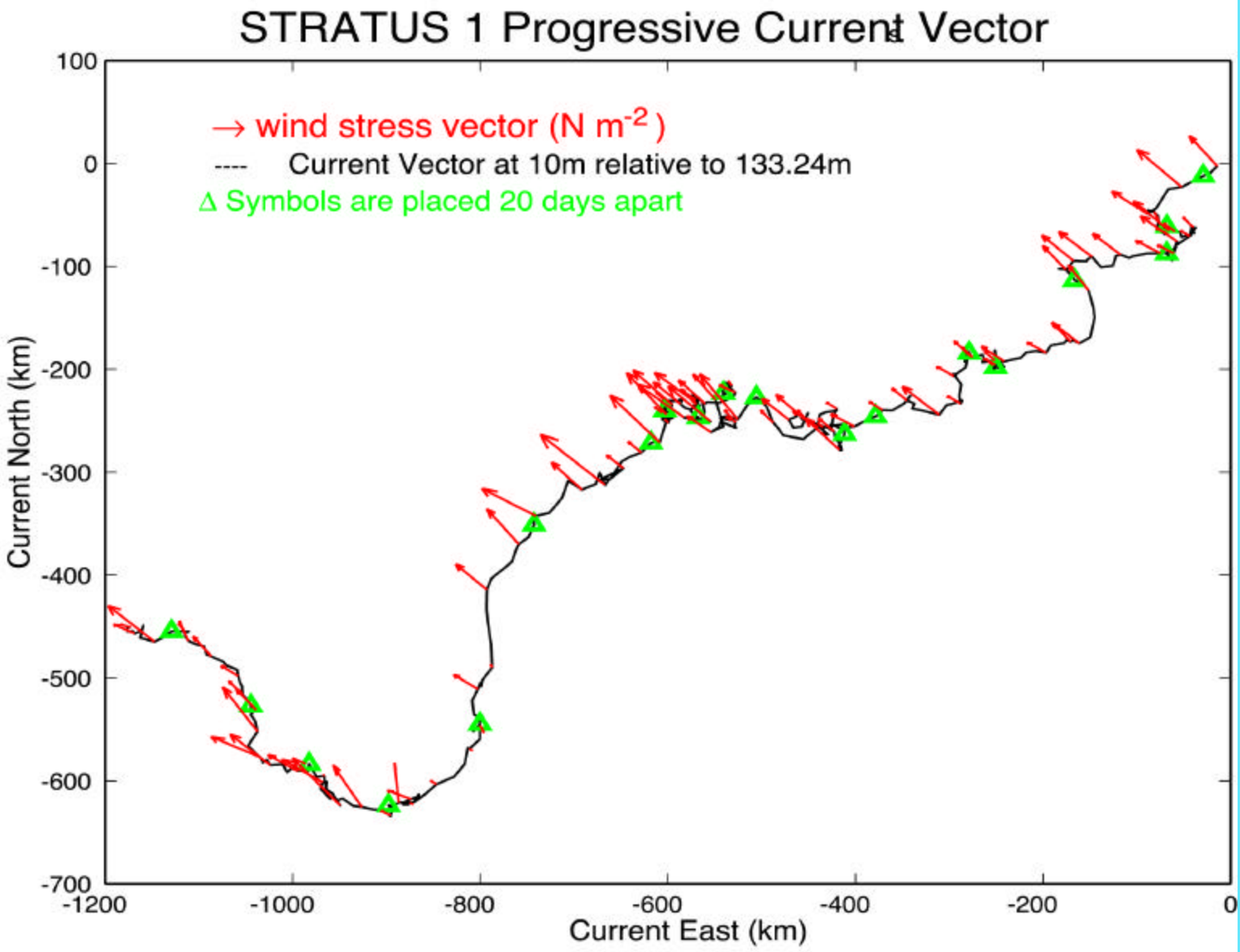




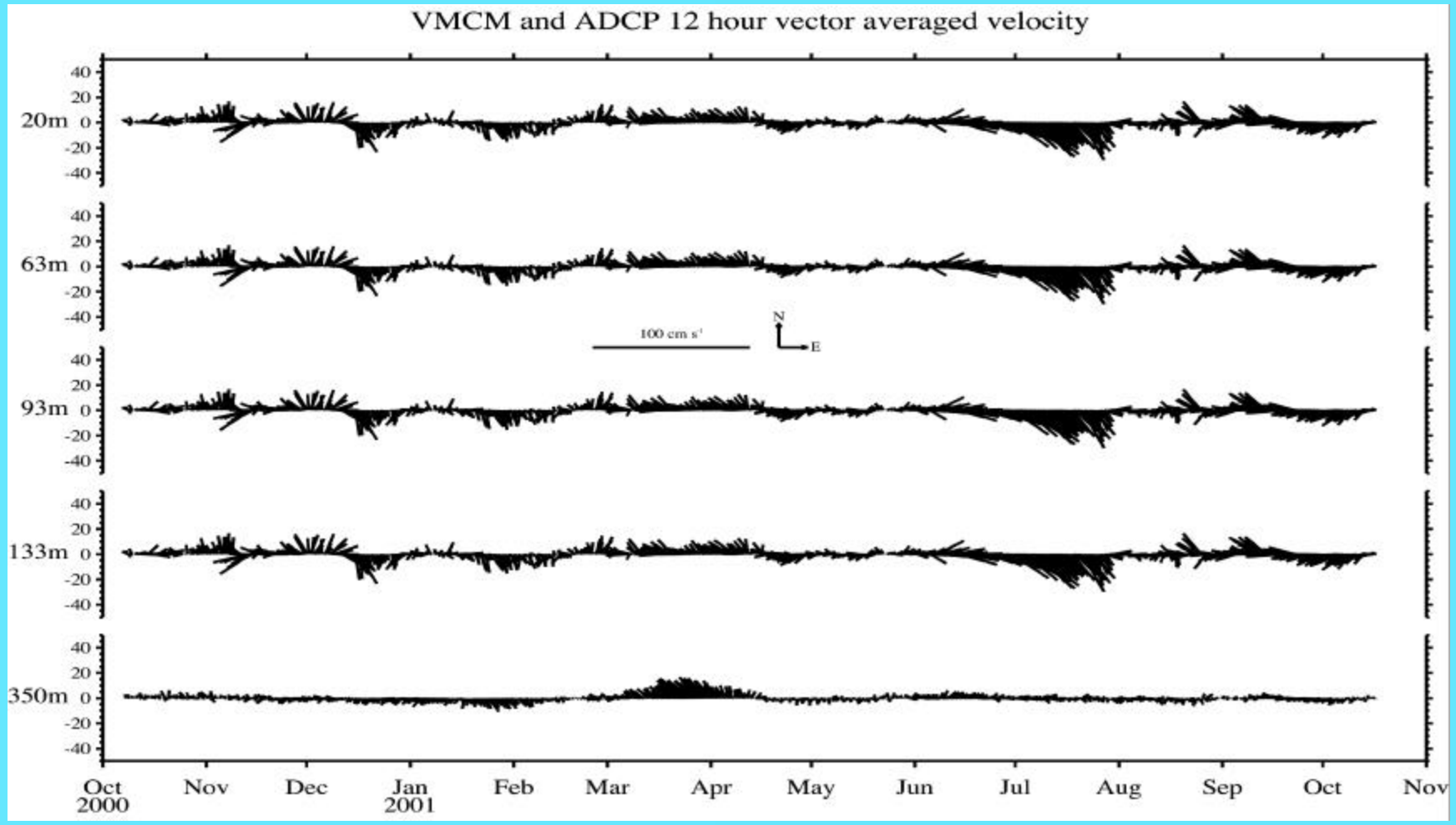
Close to one-dimensional balance in the upper ocean?



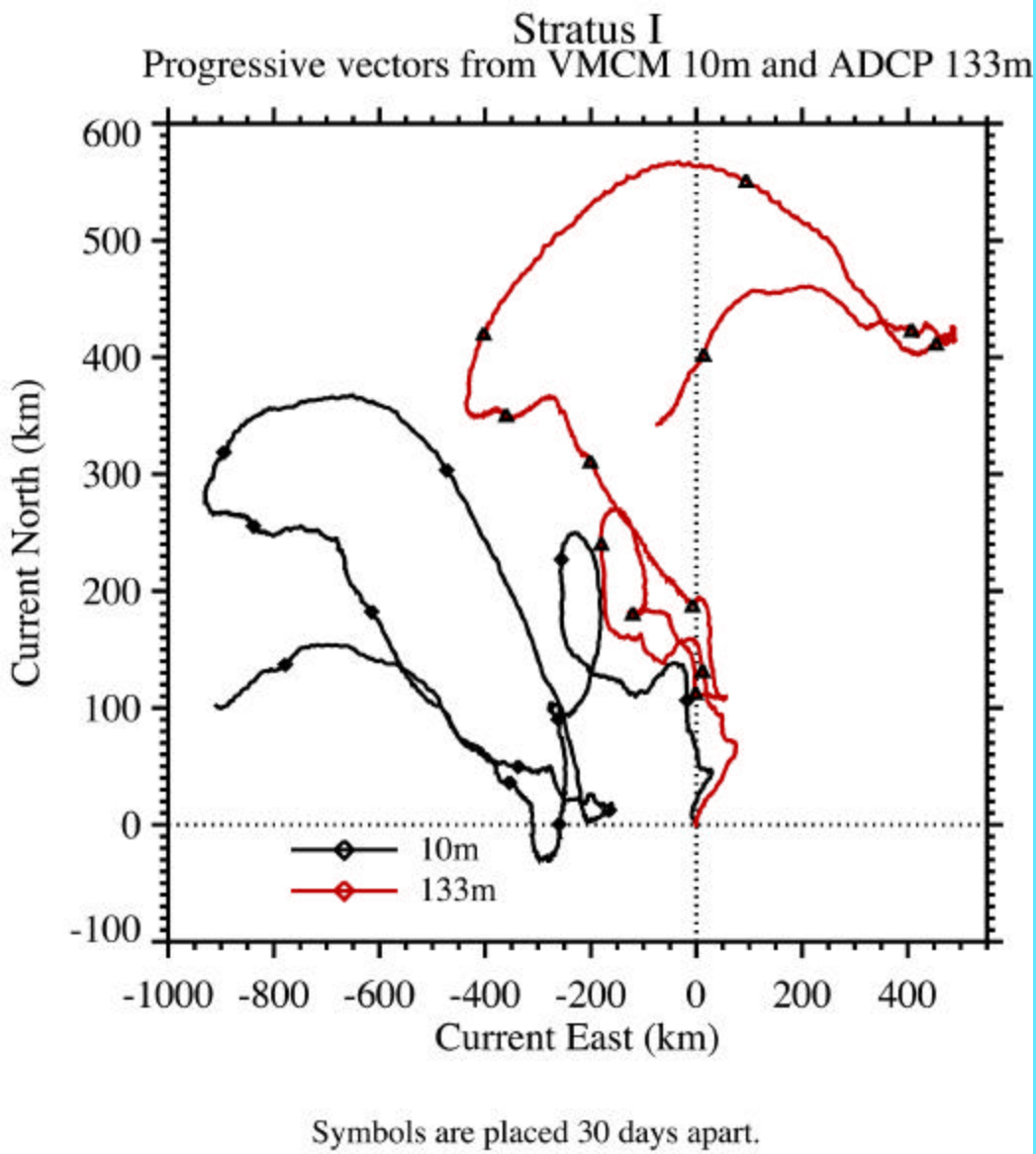
Ekman transport to the northwest; this brings cool water from coast.

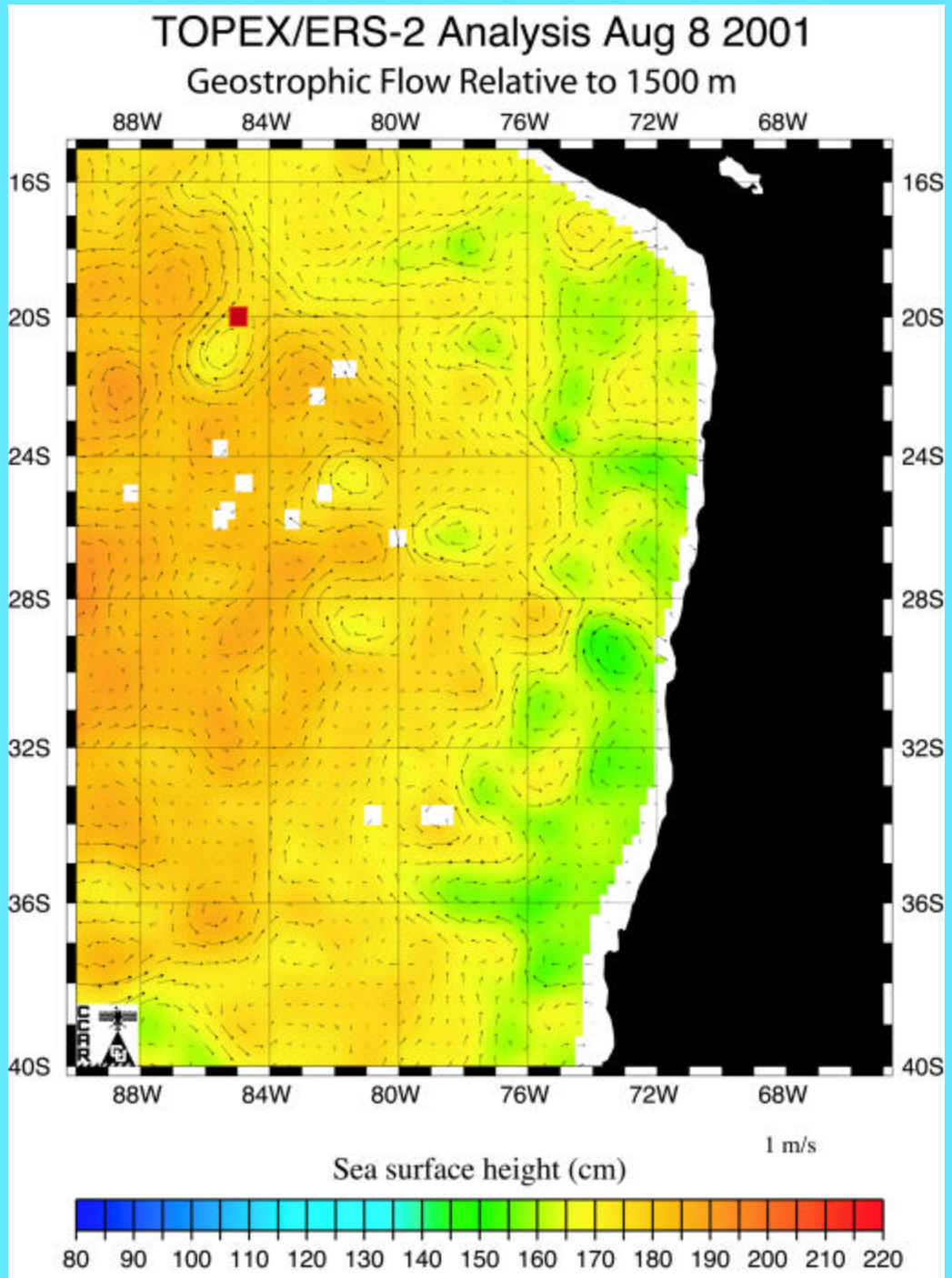


Upper ocean variability under the stratus deck; eddies dominate velocities and may play a role in heat budget.



Upper ocean variability under the stratus deck





Eddies may help carry cool upwelled water out from coast. The eddies may provide a link to coastal trapped waves originating from equatorial Kelvin waves and thus be a means by which ENSO can modulate SST in the stratus region.

Summary at 20°S, 85°W

- Accurate in-situ surface meteorology and air-sea fluxes, 52 W m^{-2} annual gain by ocean in year 1, 22 W m^{-2} in year 2.

- Differences from climatology and model surface fields, which have up to 74 W m^{-2} smaller net heat flux

- Surface met and fluxes shared via ftp not used for initialization; used to check experimental changes to NWP models, in SURFA/AMIP, to build better local flux fields, to evaluate operational models and satellite data

- Strong seasonal cycle in upper ocean response, warming and becoming more saline in southern summer

- Diurnal variability in surface forcing, at times in upper ocean, as trade winds sag may be key to seasonal warming

- Some of the upper ocean variability is linked to local air-sea interaction

- Cooling of on average of 50 W m^{-2} and freshening equal to 1.2 m yr^{-1} rainfall occurs by other processes

- Eddies influence local heat balance, provide a link as Rossby waves to coastal trapped waves and hence to equatorial Kelvin waves