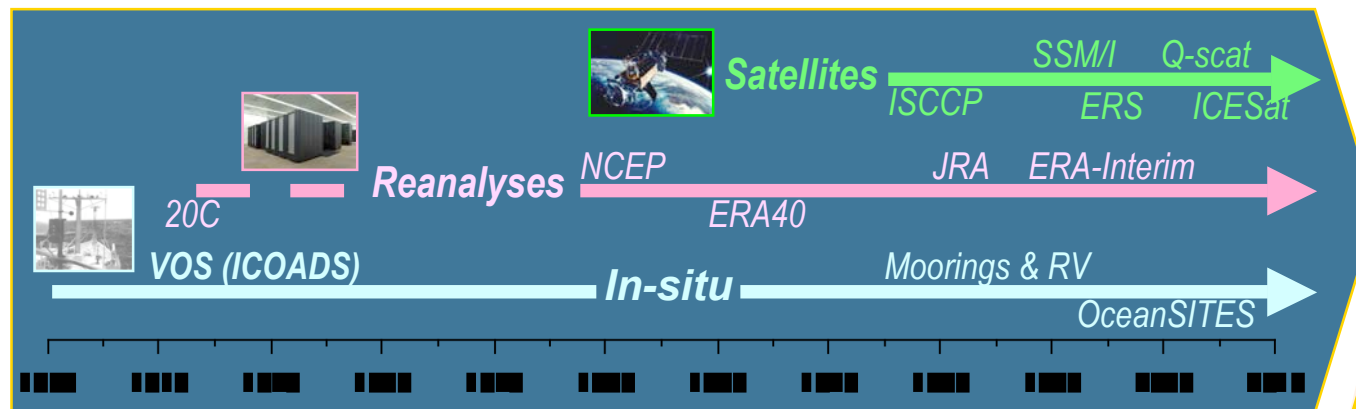


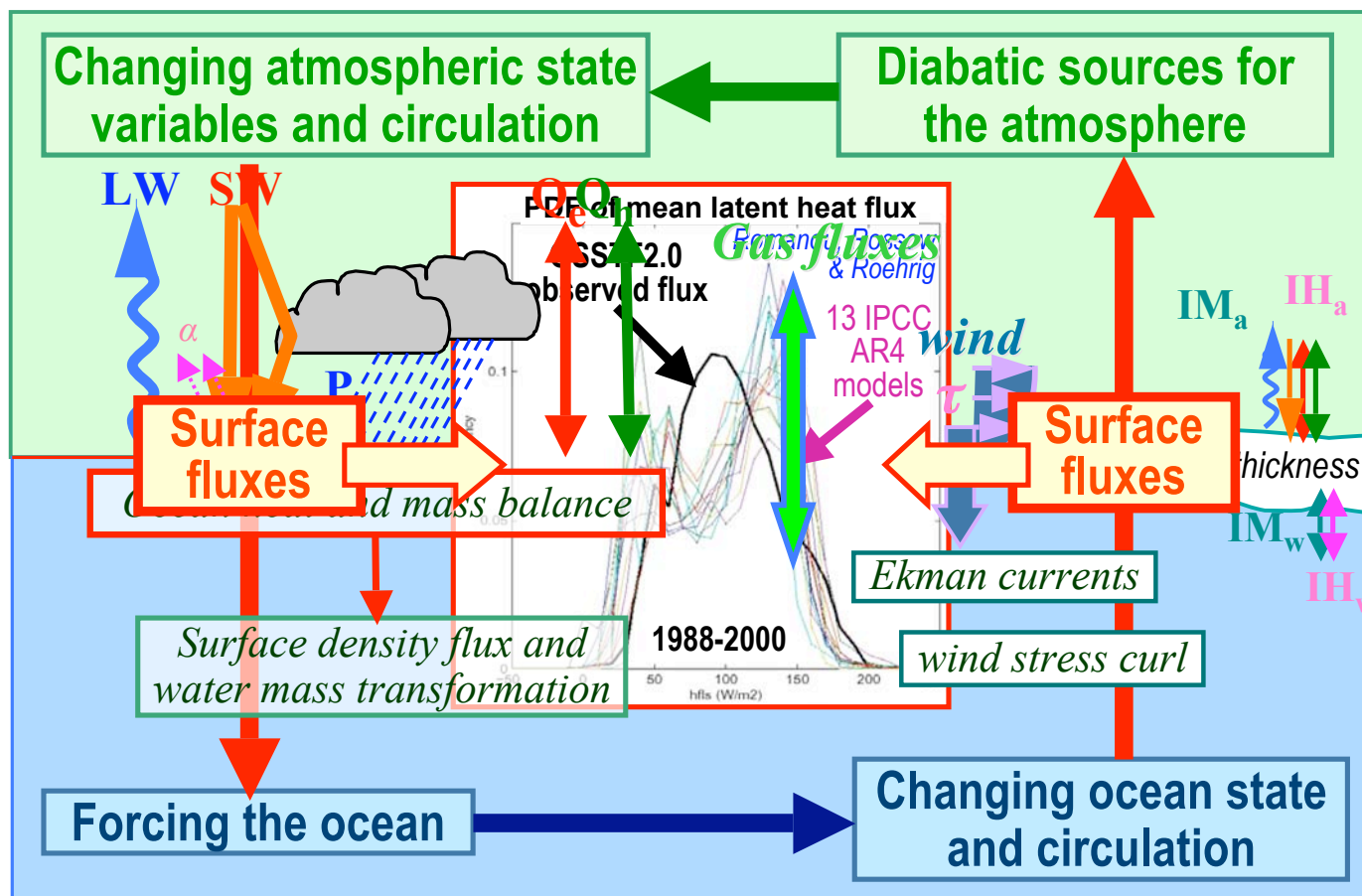
# Surface fluxes and sea ice

## Outline:



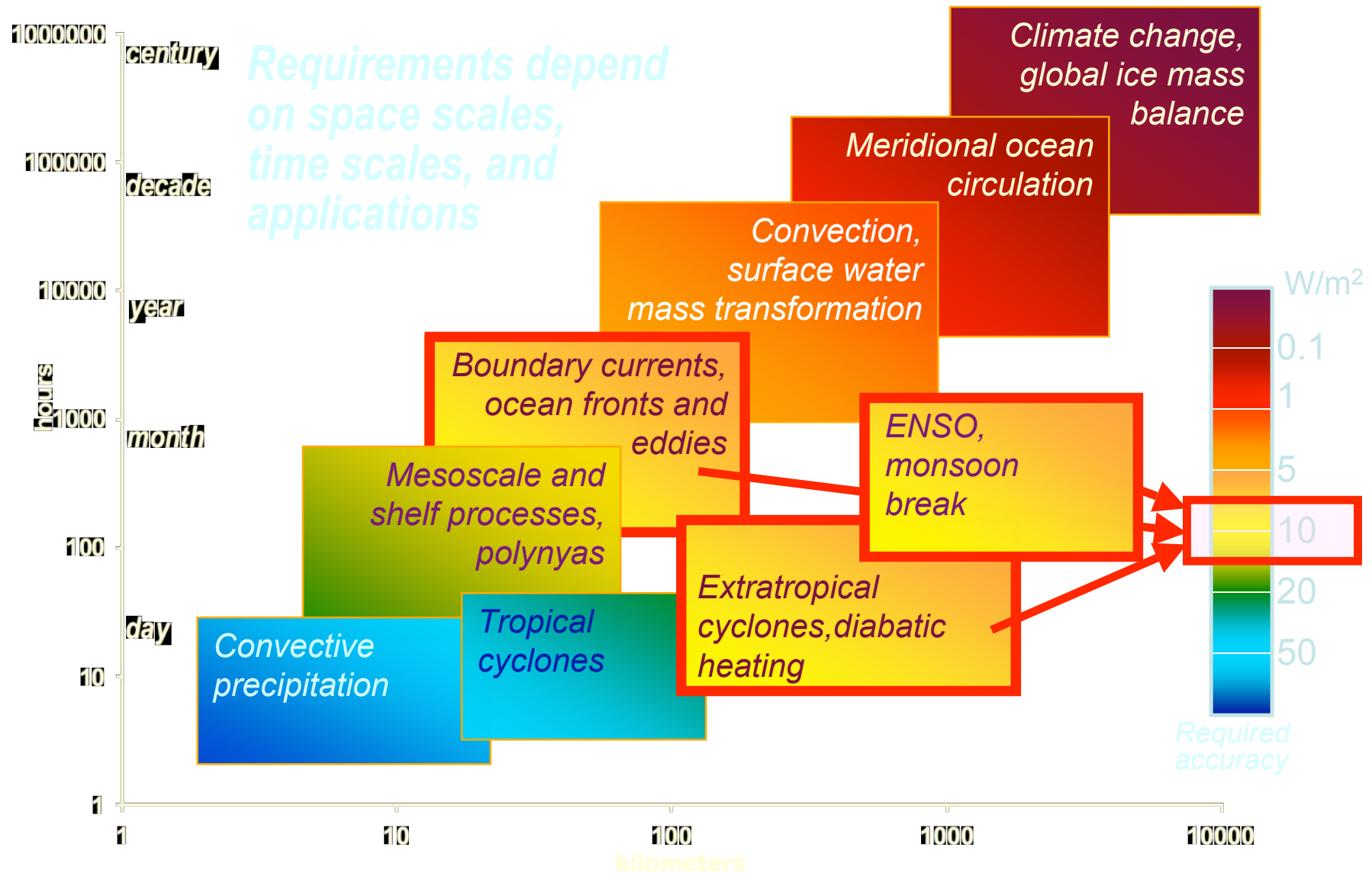
S. K. Gulev  
S. A. Josey  
M. Bourassa  
L.-A. Breivik  
M. F. Cronin  
C. Fairall  
S. Gille  
E. C. Kent  
C. M. Lee  
M. J. McPhaden  
P. M. S. Monteiro  
U. Schuster  
S. R. Smith  
K.E. Trenberth  
D. Wallace  
S.D. Woodruff

# Air-sea fluxes and ice: shaping ocean-atmosphere coupling

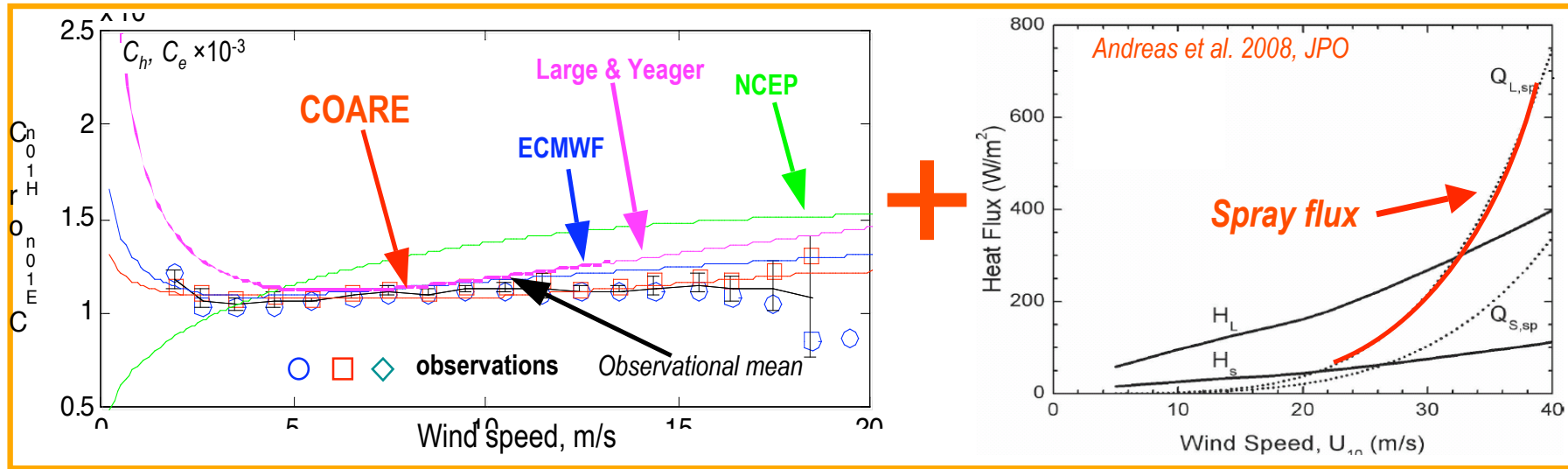


- ❑ Biases in fluxes lead to the systematic errors in climate models and preclude their efficient use in climate simulation
- ❑ Without accurate surface fluxes it is impossible to engage predictive potential of the ocean into weather and climate prediction

# Which accuracy and resolution do we need?



# Progress on parameterizations: turbulent fluxes of heat & momentum



- We have extensive in-situ data to rely on
- Advanced parameterizations are successfully matching them

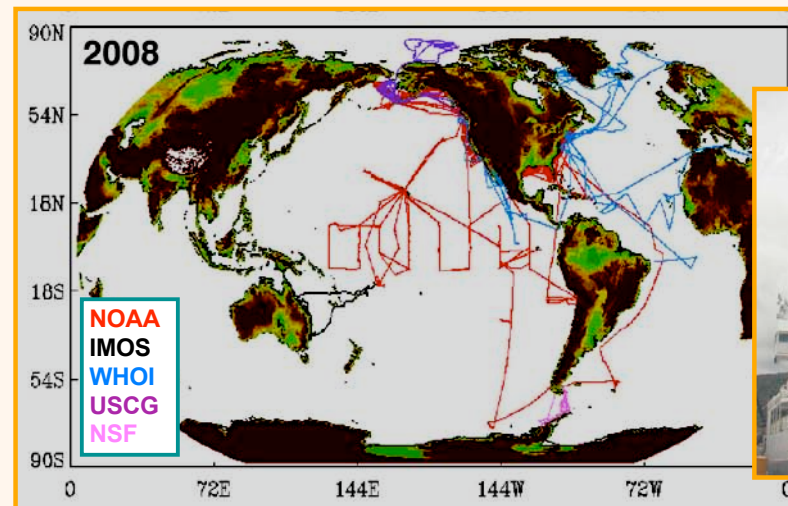
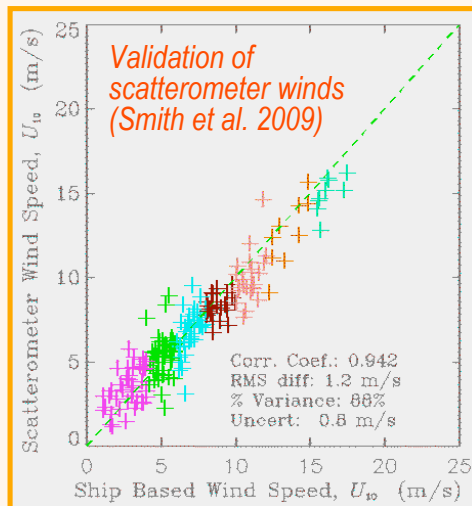
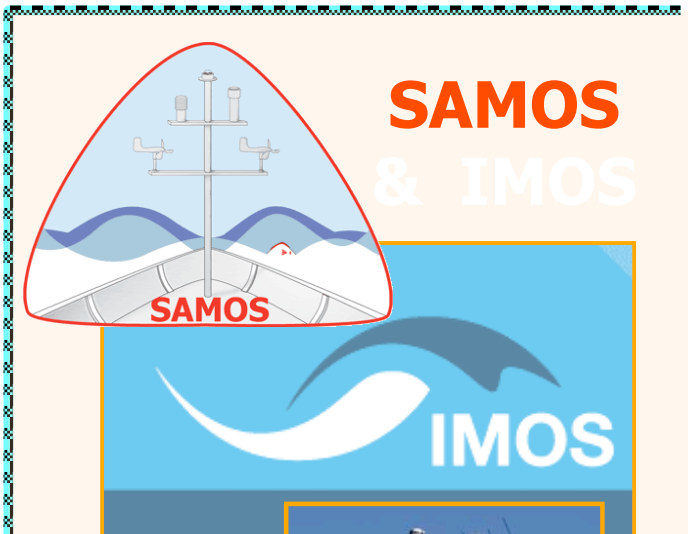
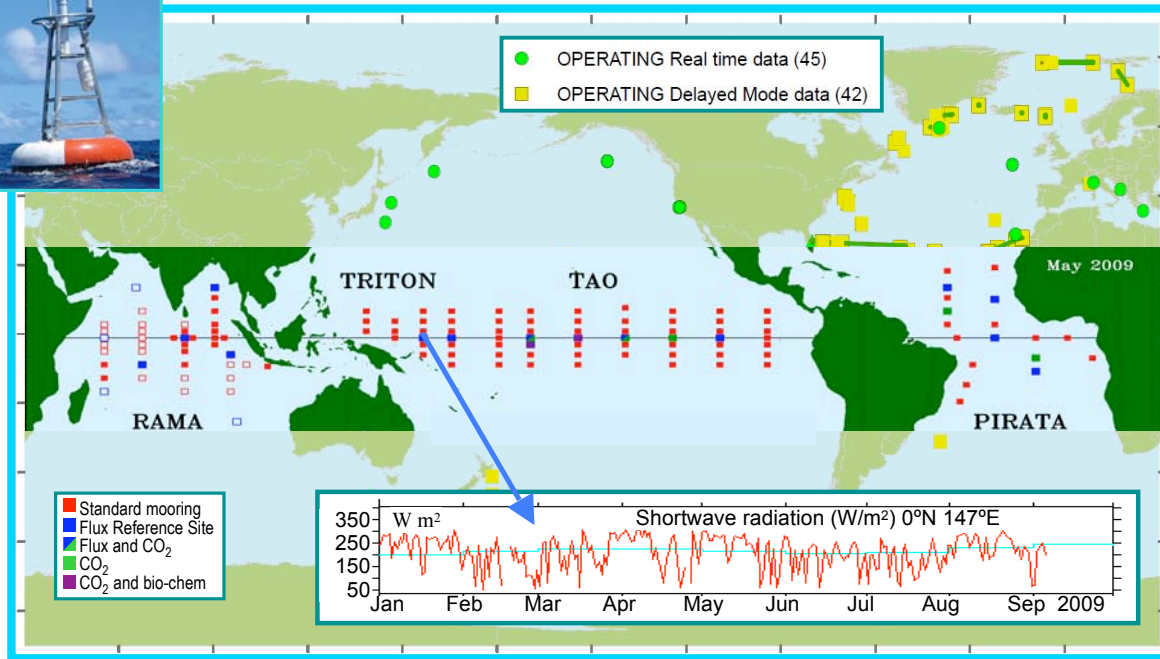


Seamless approach across wind and stability conditions

OceanObs'09

21-25 September – Venice, Italy

# Surface fluxes from in-situ: buoys & RV

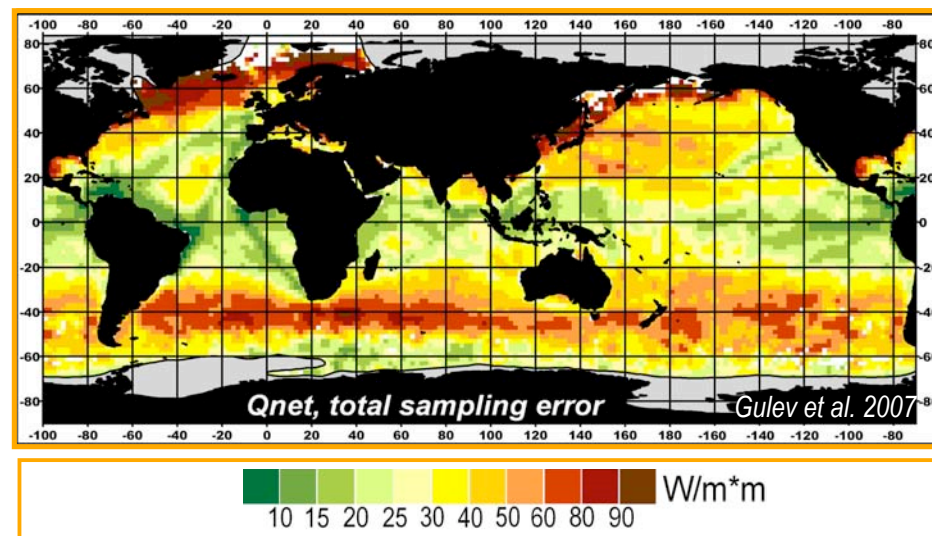
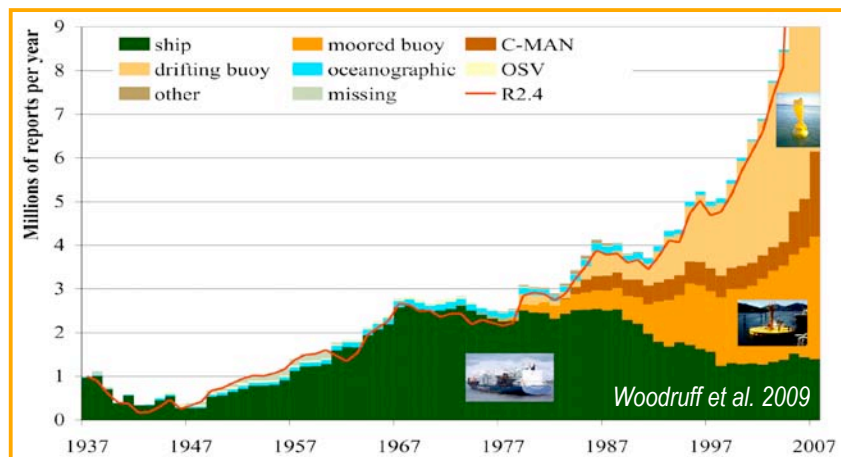


**OceanObs'09**

21-25 September – Venice, Italy



# Surface fluxes from *in-situ*: VOS



## 1999: NOC1.1 (SOC) climatology:

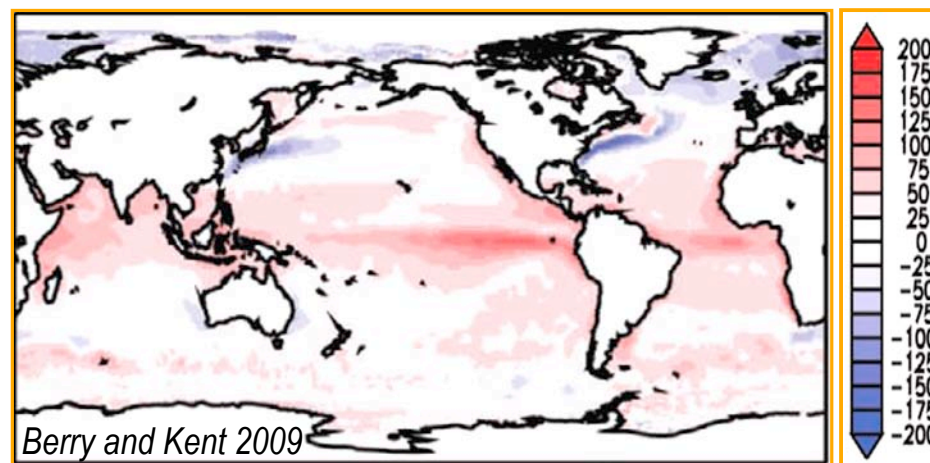
- ❑ 1979-1993, monthly
- ❑ variable corrections, WMO-47
- ❑ successive correction

Global imbalance: **30 W/m²**

## 2009: NOC-2.0 climatology:

- ❑ 1973-2006, daily,
- ❑ updated variable corrections, WMO-47
- ❑ fluxes from optimally interpolated variables
- ❑ uncertainty estimates for all fluxes

Global imbalance: **24 W/m²**



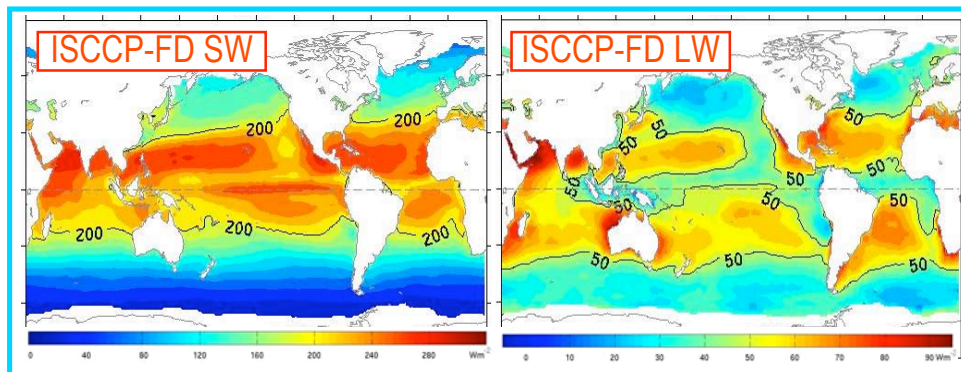
**The problem of global closure in VOS still remains unresolved!**

**OceanObs'09**

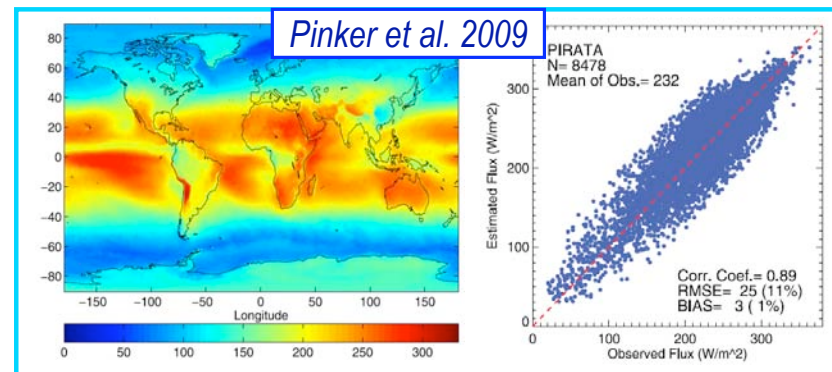
21-25 September – Venice, Italy

# Satellite-based surface fluxes

ISCCP Radiative fluxes (SW+LW):  
global, 3-hourly, 1983-onwards



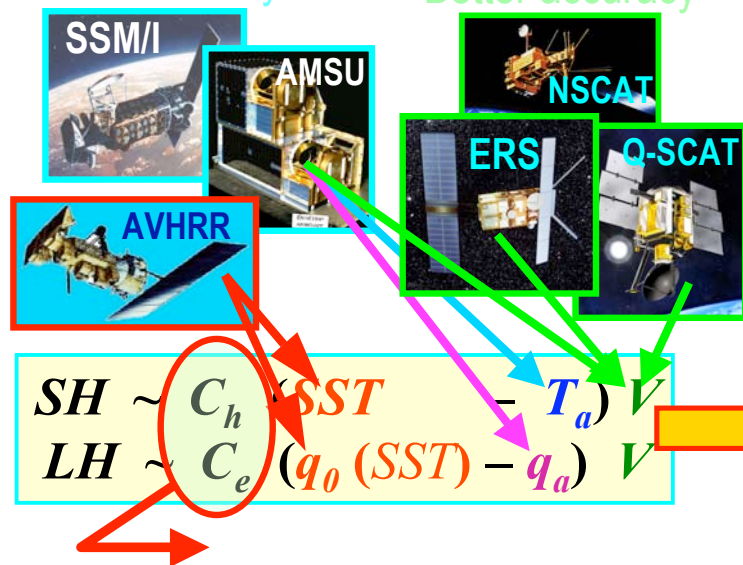
MODIS, TOVs, GOES global  
products, 2000+



Turbulent fluxes from satellites:

Low accuracy

Better accuracy

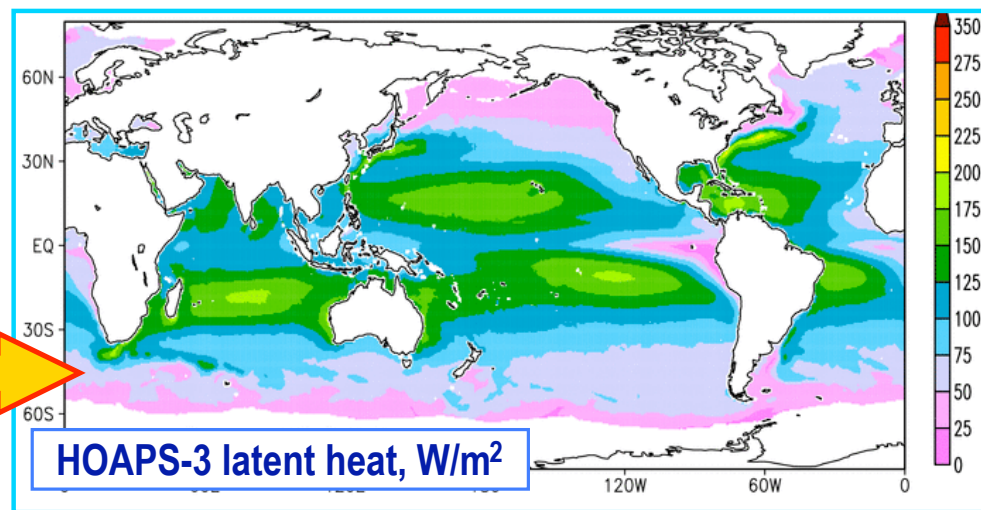


MPI-HOAPS  
(Klepp et al. 2008)

GISS-GSSTE  
(Chou et al. 2004)

J-OFURO  
(Kubota et al. 2007)

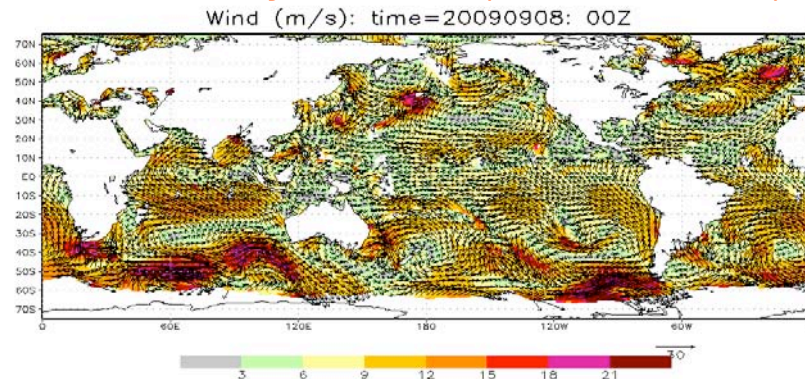
BEL (Bouras-Eymard-Liu 2002) IFREMER (Bentamy et al. 2008)





## Satellite scalar and vector winds from different missions

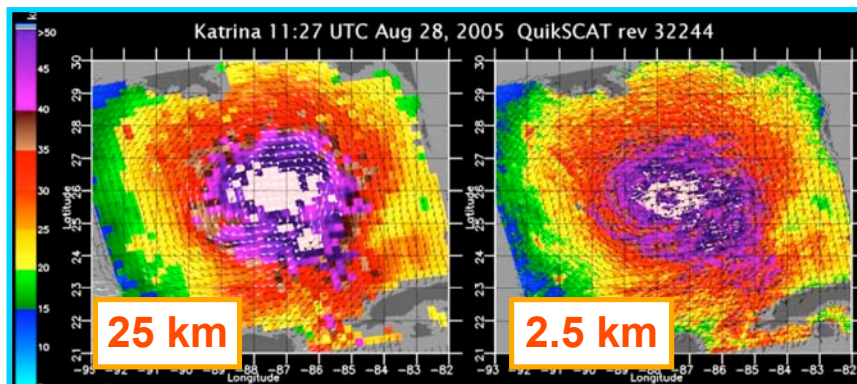
Blended NOAA 0.25° 6-hourly winds, from multiply satellites (08-09 Sep 2009)



Zhang et al. 2008

Scatterometer vector winds:

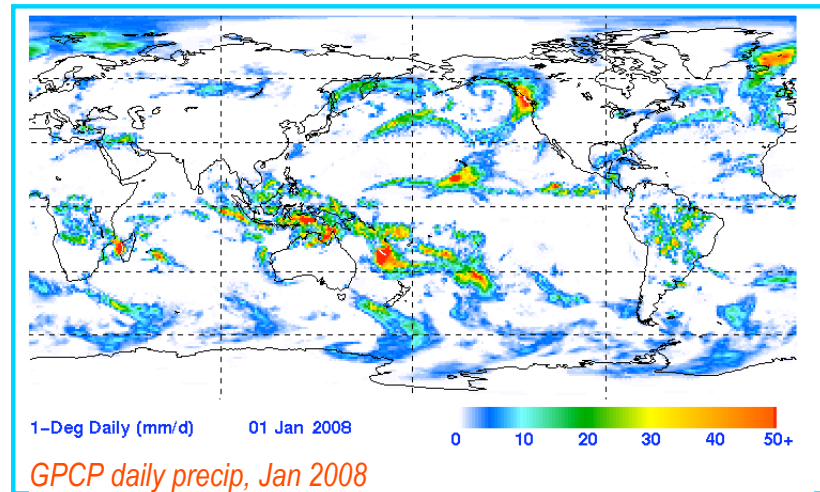
Effect of increasing resolution from 25 km to 2.5 km in representation of the Katrina's eye



## Satellite precipitation from SSM/I, AMSU, AQUA, TRMM missions

GPCP products: 1°×1°, daily, 1997+

CMORPH: 0.25°×0.25°, 3-hr, 2002+



Time resolution of satellite products reached the one of NWP with much higher spatial resolution

However ...

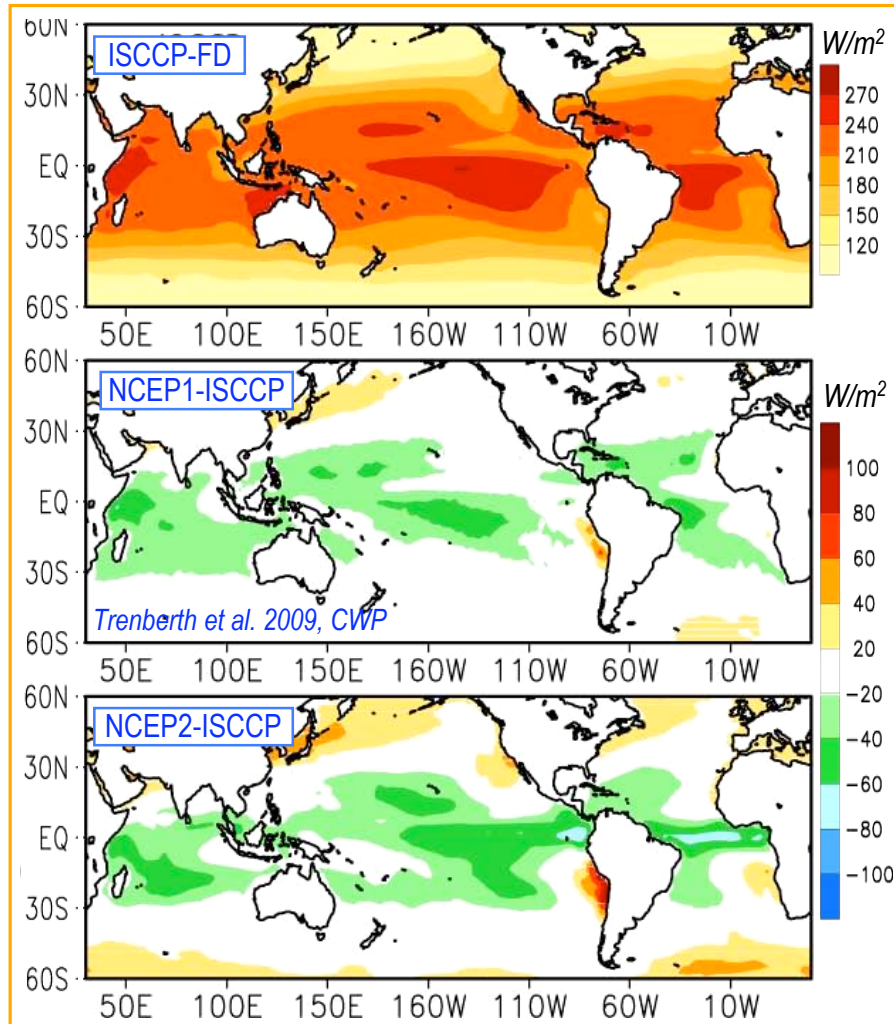
- ❑ Major problems with key variables (low accuracy of  $T_{air}$  retrieval)
- ❑ Satellites alone cannot provide surface flux products (*in-situ* data needed for validation)



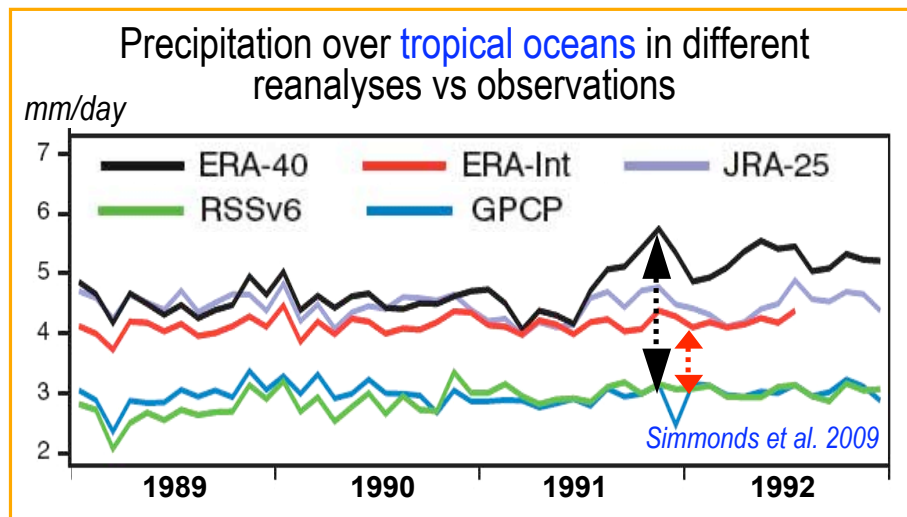
# Surface fluxes from reanalyses:

Improving resolution and accuracy, however, some large-scale biases still remain

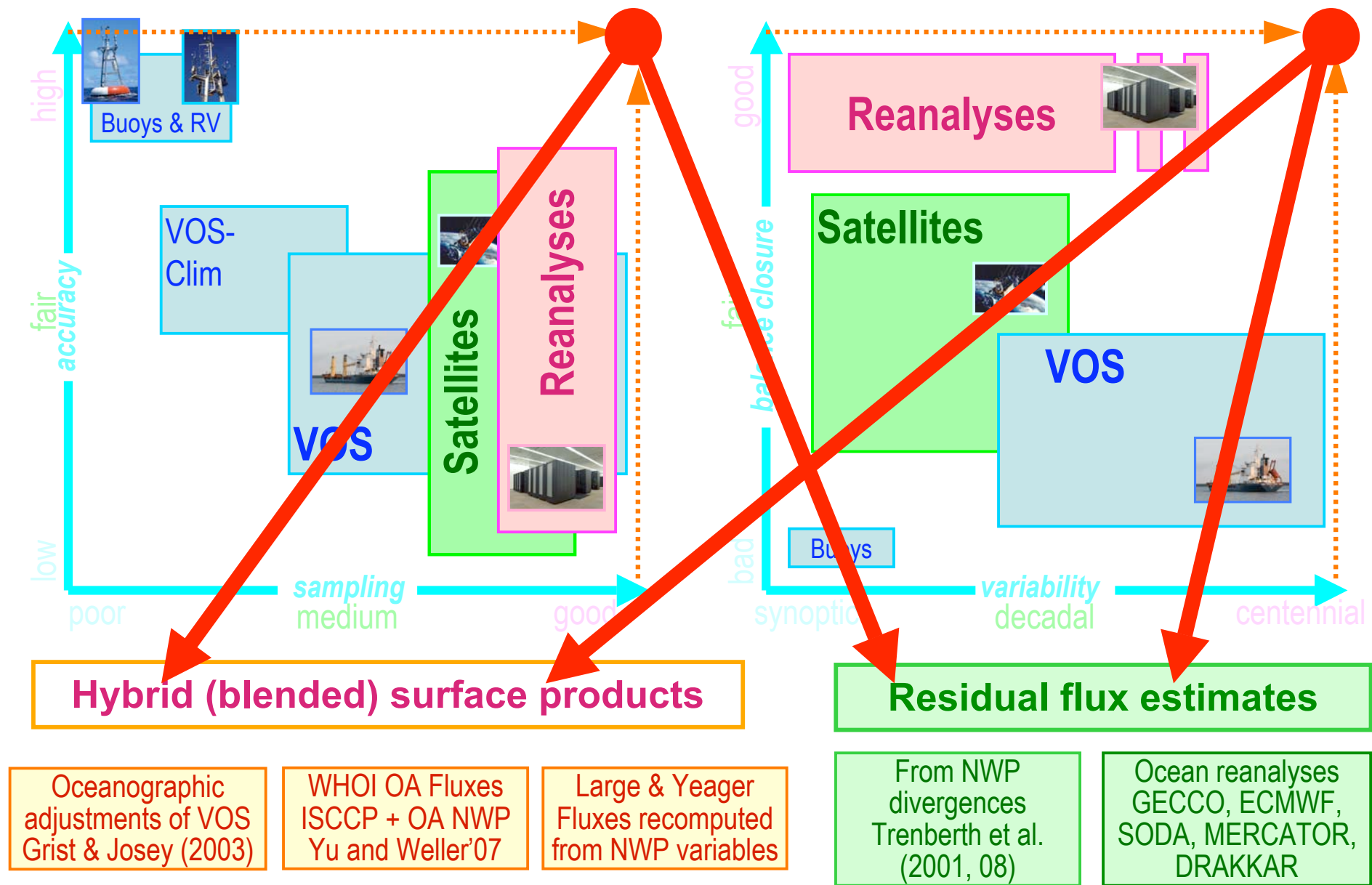
Short wave radiation: NCEP vs ISCCP



ERA-Interim precipitation improvements

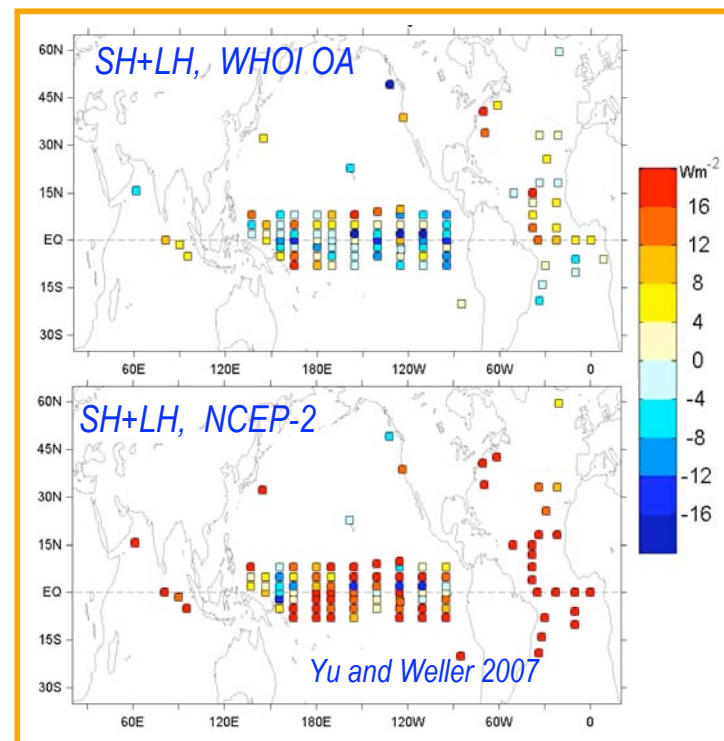
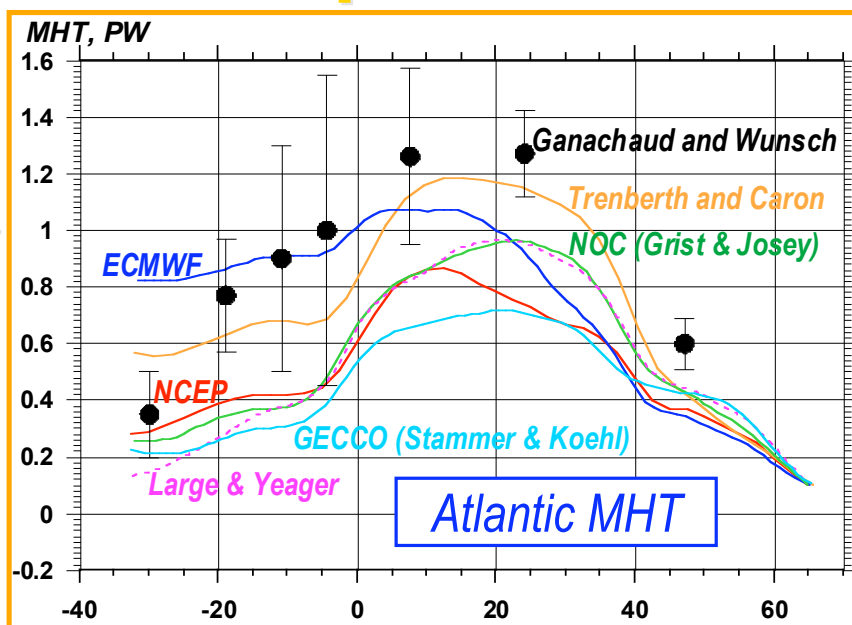


# Is there a "fit-for-all" flux product?

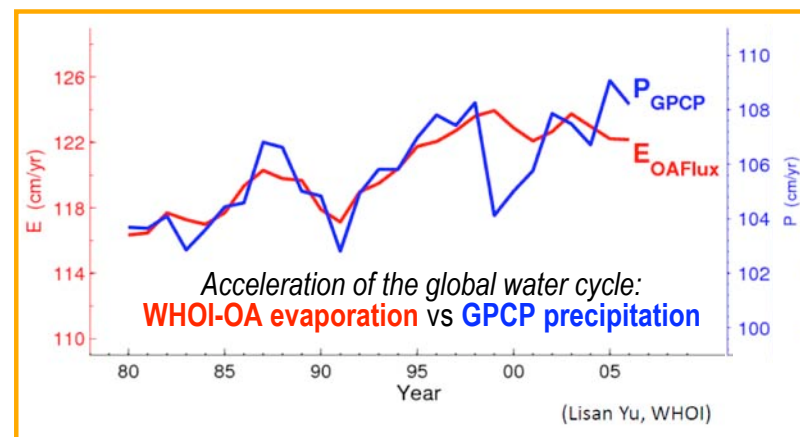
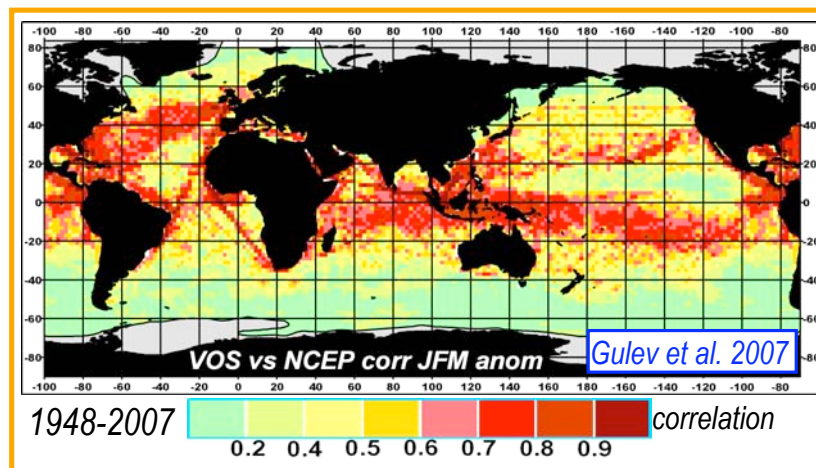


# Is there a "fit-for-all" flux product?

Regional  
balances  
and MHT



Variability  
and  
trends





# Ocean-atmosphere gas fluxes

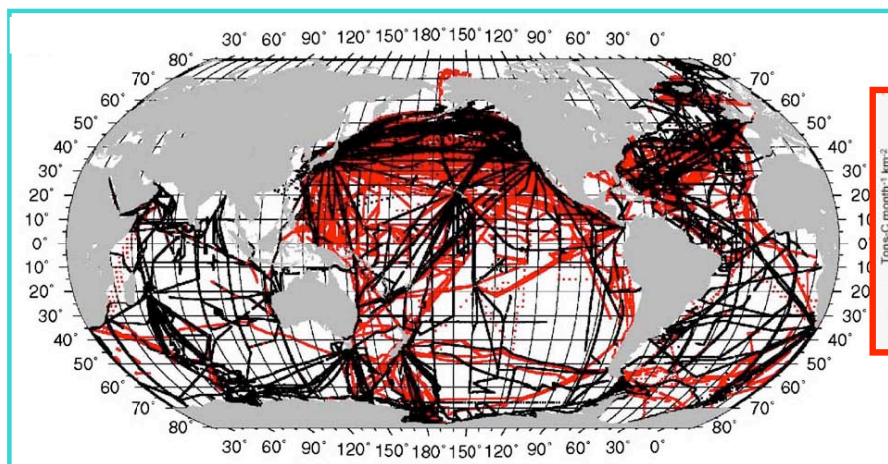
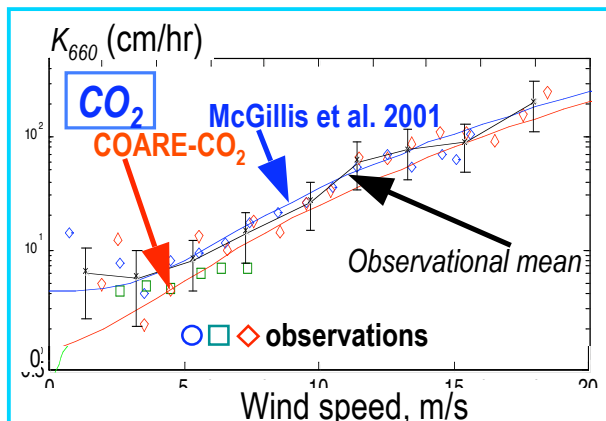
- Standardization of methods and platforms



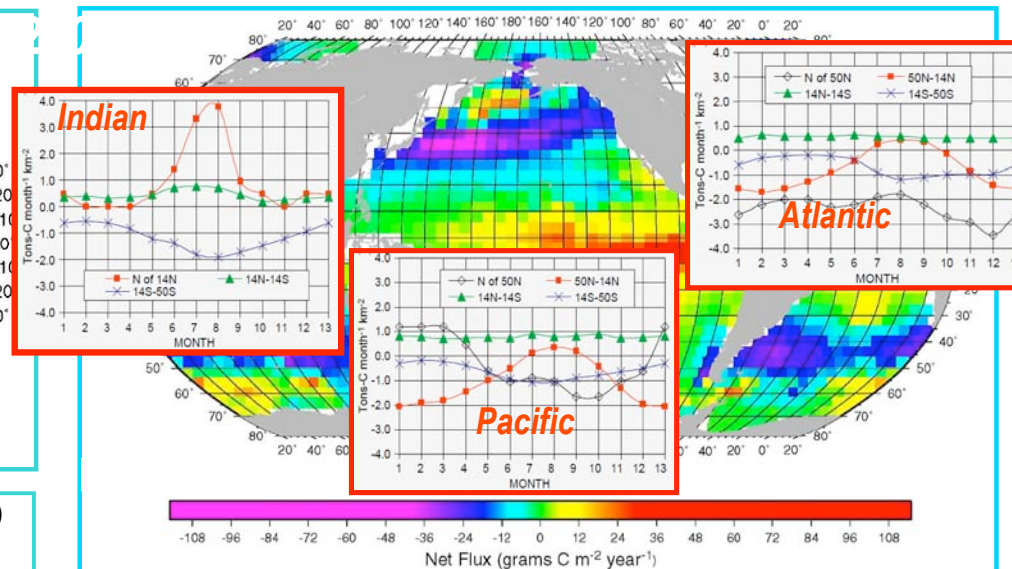
- SEASAW, DOGEE & HiWASE campaigns



- Surface Ocean CO2 Atlas (SOCAT): 1968-2007

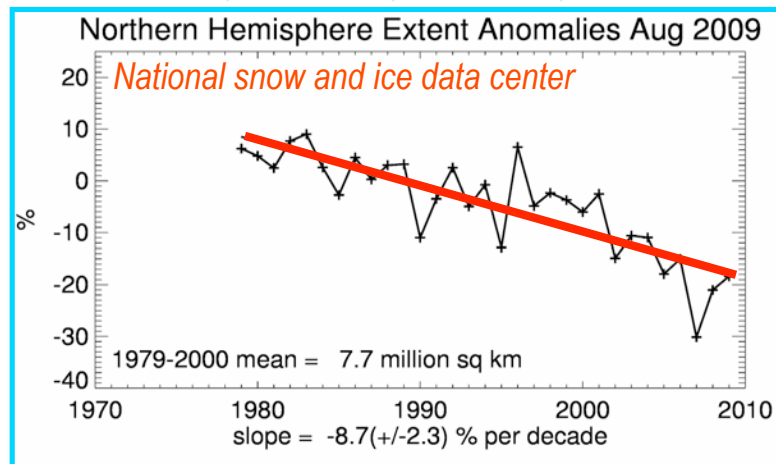
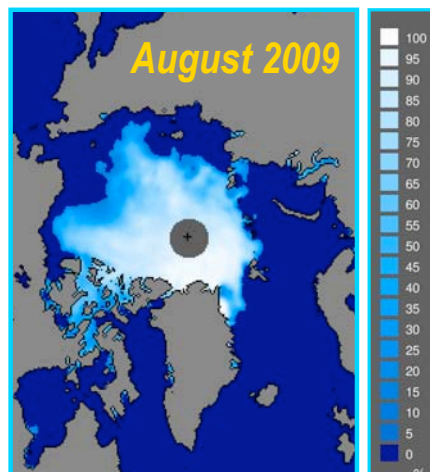


— 0.94M observations (Takahashi et al. 2002)  
— 3M observations (Takahashi et al. 2009)

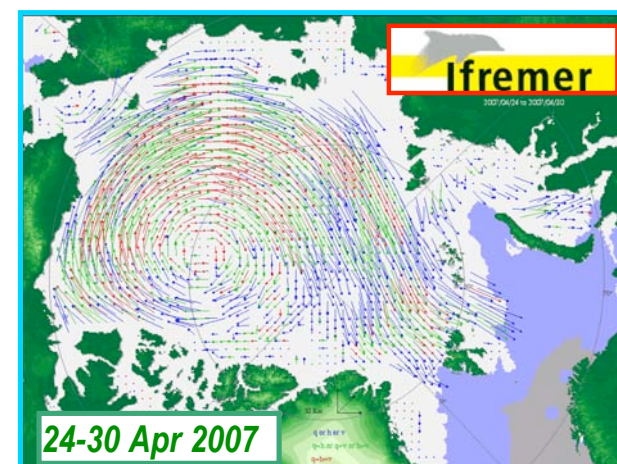


# Satellite-based sea-ice products: cover, concentration, motion and thickness

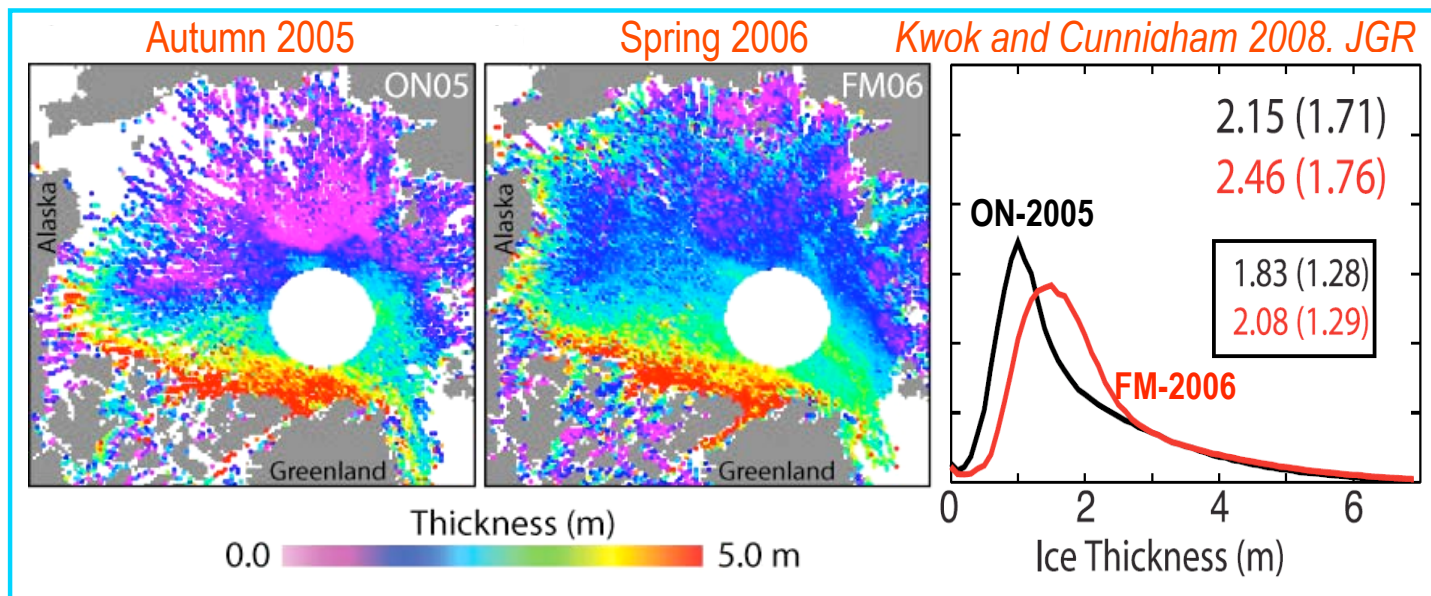
Sea ice concentration: SSM/I, SSMR, AMSU, AMSR



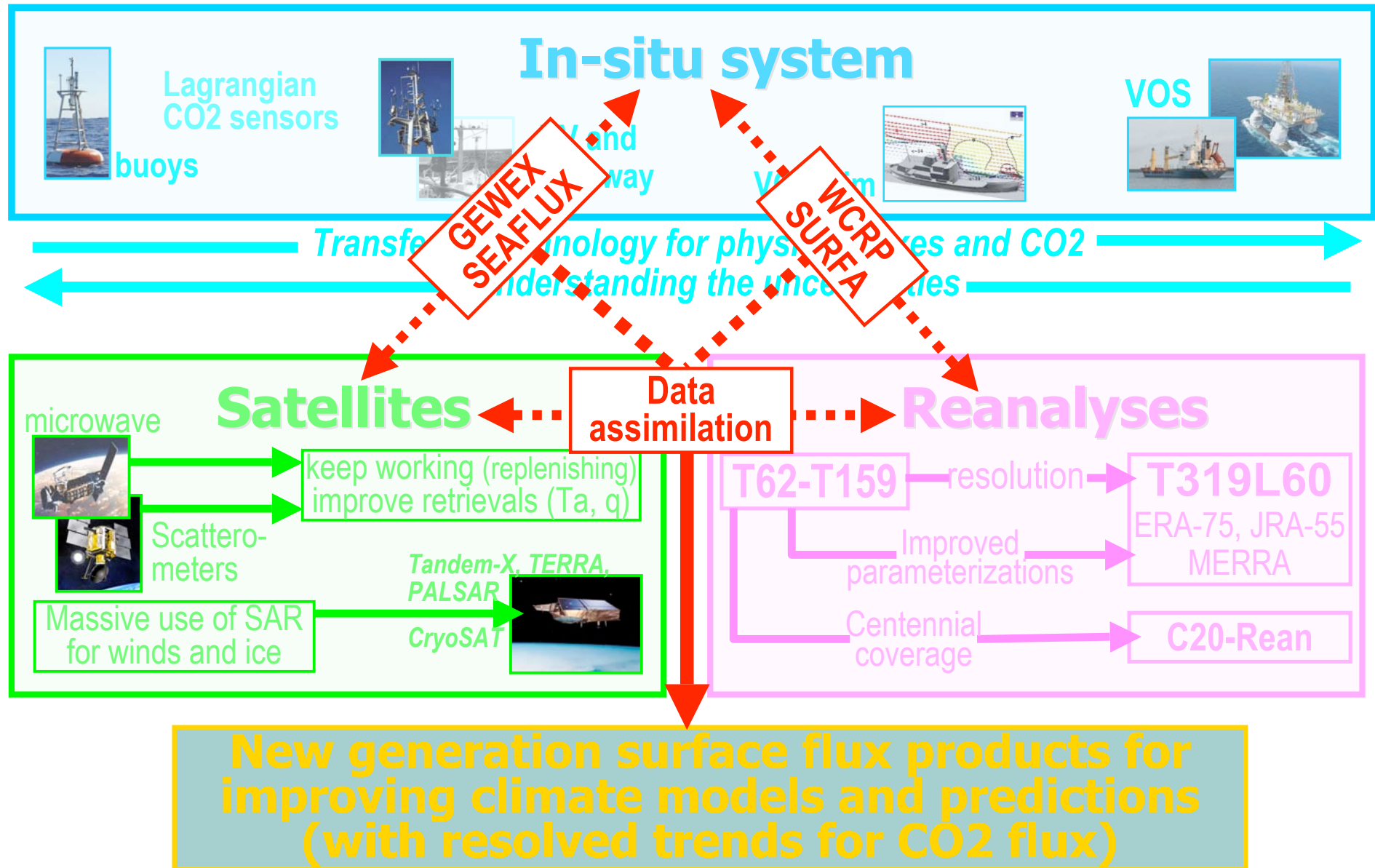
SSM/I + Q-Scat ice drift, 62-km



Sea ice freeboard  
and thickness

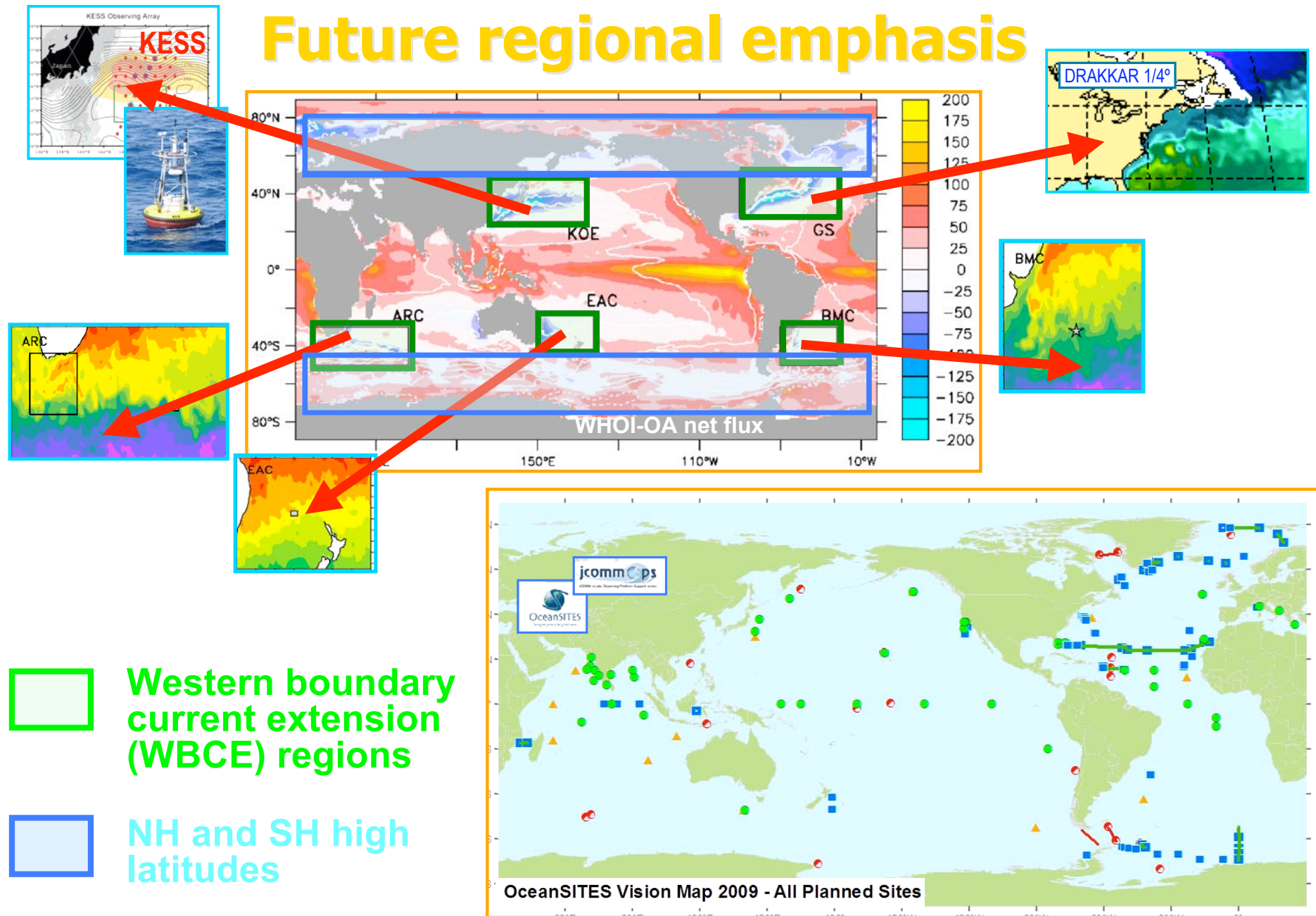


# SUMMARY: vision for the future





# Future regional emphasis



# Conclusions and recommendations

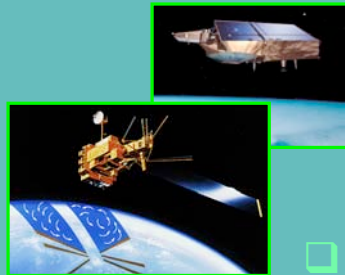
## In-situ “system of systems” ————— Global & regional closure —————

- ❑ Expansion of OceanSITES in subpolar and high latitudes, extension of packages to direct turbulent measurements including gases
- ❑ RV & underway: transfer of SAMOS to the truly international program with distributed or centralized DAC
- ❑ Drastic decline of VOS must be recognized and addressed



## ————— Cross-validated fluxes and sea ice characteristics —————

## Satellites



- ❑ Maintenance of HR global scatterometry and microwave with overlapping periods of operation
- ❑ Priorities for improved retrievals of temperature, whitecaps, humidity, precip, and improved sampling for vector winds
- ❑ Improved access to SAR data on winds and sea-ice characteristics

## NWP and reanalyses ————— Engaging ocean in climate prediction —————

- ❑ Improvement of the space-time resolution and temporal coverage
- ❑ Minimizing uncertainties by improving the whole system
- ❑ Coupled reanalyses will hold the best prospect for spurring NWP advances and reducing biases due to currents and waves



## ————— WCRP, WMO, IOC: —————

- ❑ International coordinating and facilitating body is needed

**Thank you**  
**and**  
**all authors of CWPs used,**  
**especially:**

**Claus Boening, Armin Koehl,  
Bill Large, Wade McGillis,  
Vladimir Ryabinin,  
Detlef Stammer, Bob Weller,  
Steve Yeager, Lisan Yu**