OOPC Ocean Observations Panel for Climate

Select US and International Programs
Flux-Related Programs

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GCOS Global Climate Observing System
GOOS Global Ocean Observing System
WCRP World Climate Research Programme
jcomm Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology

IOC WMO UNEP ICSU

Outline

- Recognized Relevance of Fluxes by National and International Programs
- Upcoming Activities that are critically dependent on fluxes
  - Earth Systems Modeling
  - Grand Challenges

- International groups that focus on observational requirements for climate
  - Many groups (3 or 4 letter acronyms) want to establish requirements
  - As of yet, there are few requirements on surface fluxes
  - Most flux-related bulk variables are considered, but not for fluxes

- A new Implementation Plan for the Global Climate Observing System
  - To be drafted late 2016
  - We are considering adding surface fluxes and Essential Climate Variab les

Recognized Relevance of Fluxes

- National Programs
  - NASA NEWS – NASA Energy and Water Cycle
    - Contributions to the Energy and Water Cycle
  - NOAA Climate Observing Division (COD)
  - National Ocean Forecasting Agencies
- International Programs
  - TIE-OHC
  - Seaflux
  - WCRP – World Climate Research Program
    - GEWEX – Global Energy and Water EXchanges
    - CLIVAR
  - Research Coordination Network (RCN)
  - Global Ocean Observing System (GOOS)
  - Global Climate Observing System (GCOS)

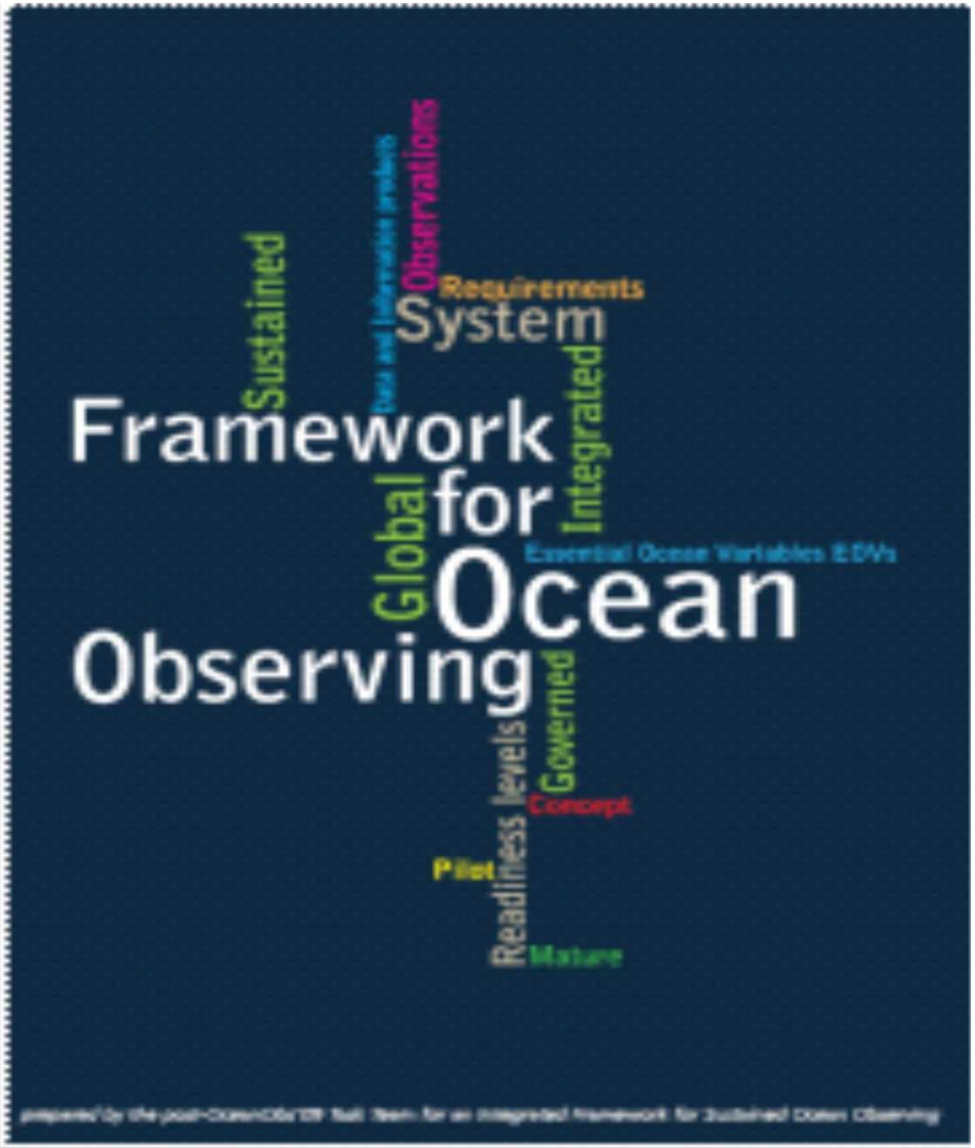
US National Programs – Potential for collaboration

- **NASA NEWS – NASA Energy and Water Cycle**
  - Contributions to the Energy and Water Cycle
  - A new team was put together in late 2014 and early 2015
    - A plausible group for collaboration
- **NOAA Climate Observing Division (COD)**
  - Researchers identified surface fluxes as the leading cause of error
- **National Ocean Forecasting Agencies**
  - For example, the US Naval Research Laboratory
  - Some of these have strong programs on satellite remote sensing and on surface fluxes

High Level International Programs

- WCRP – World Climate Research Program
  - Trying to understand the water and energy cycle
  - Climate Variability in the Oceans
  - WCRP, ECMWF, and NCAR are all moving forward or planning to move forward with **Earth Systems Modeling**
    - Surface fluxes will become of greater importance for validation of processes
- Research Coordination Network (RCN)
  - Supported by US National Science Foundation, IGARSS, others?
  - Crosses disciplines and geographical boundaries
- Global Ocean Observing System (GOOS)
  - Folks that Brought us the Framework for Ocean Observations
  - Brings together physical, biogeochemical, and biological programs
- Global Climate Observing System (GCOS)
  - Sets requirements for climate quality observations
  - Considering elevating the importance of surface fluxes

GOOS’s Framework for Ocean Observations (the FOO)



- An outcome of OceanObs’09
- Codifies best practices
- Based on feedbacks between
  - Observations
  - Research
  - Applications
- GOOS, RCN, and other (e.g., IOOS and SOOS) all categorize their key variables as Essential Ocean Variables (EOVs)
- GCOS focuses on Essential Climate Variables (ECVs)

Global Climate Observing System (GCOS)

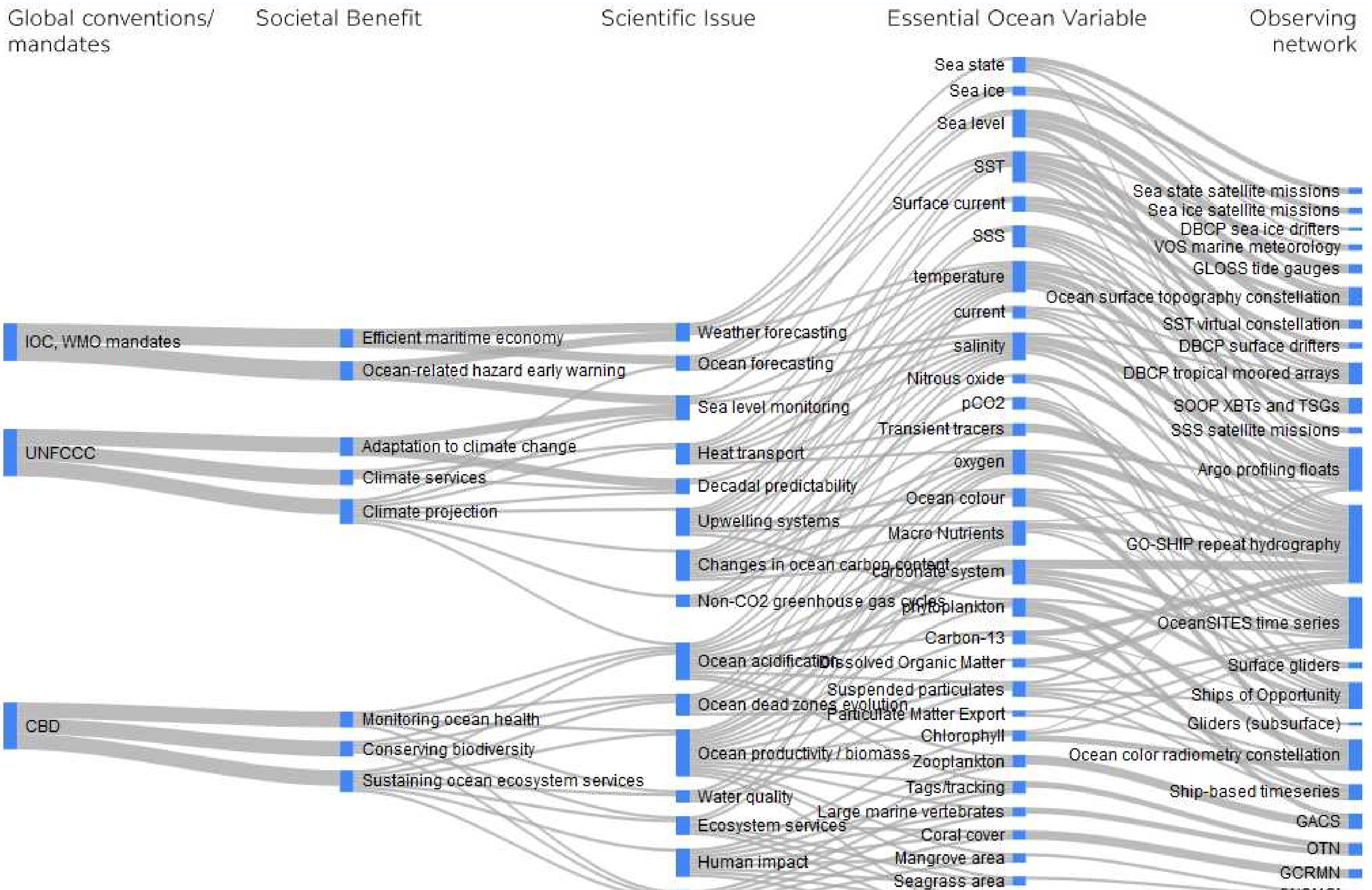
- GCOS is divided into three panels
  - Atmospheric Observation Panel for Climate (AOPC)
  - Terrestrial Observation Panel for Climate (TOPC)
  - Ocean Observation Panel for Climate (OOPC)
- GCOS was designed to parallel the IPCC, and provide observations to the IPCC
  - GCOS is recognized by many high level organizations as the group tha t:
    - Lists key climate variables that should be measured
    - Sets climate-related standards for those observations
  - ECVs must be
    - Important for climate processes
    - Feasible to measure (including cost)
    - Sufficiently accurate

Sets of EOVs and ECVs Are Not Consistent

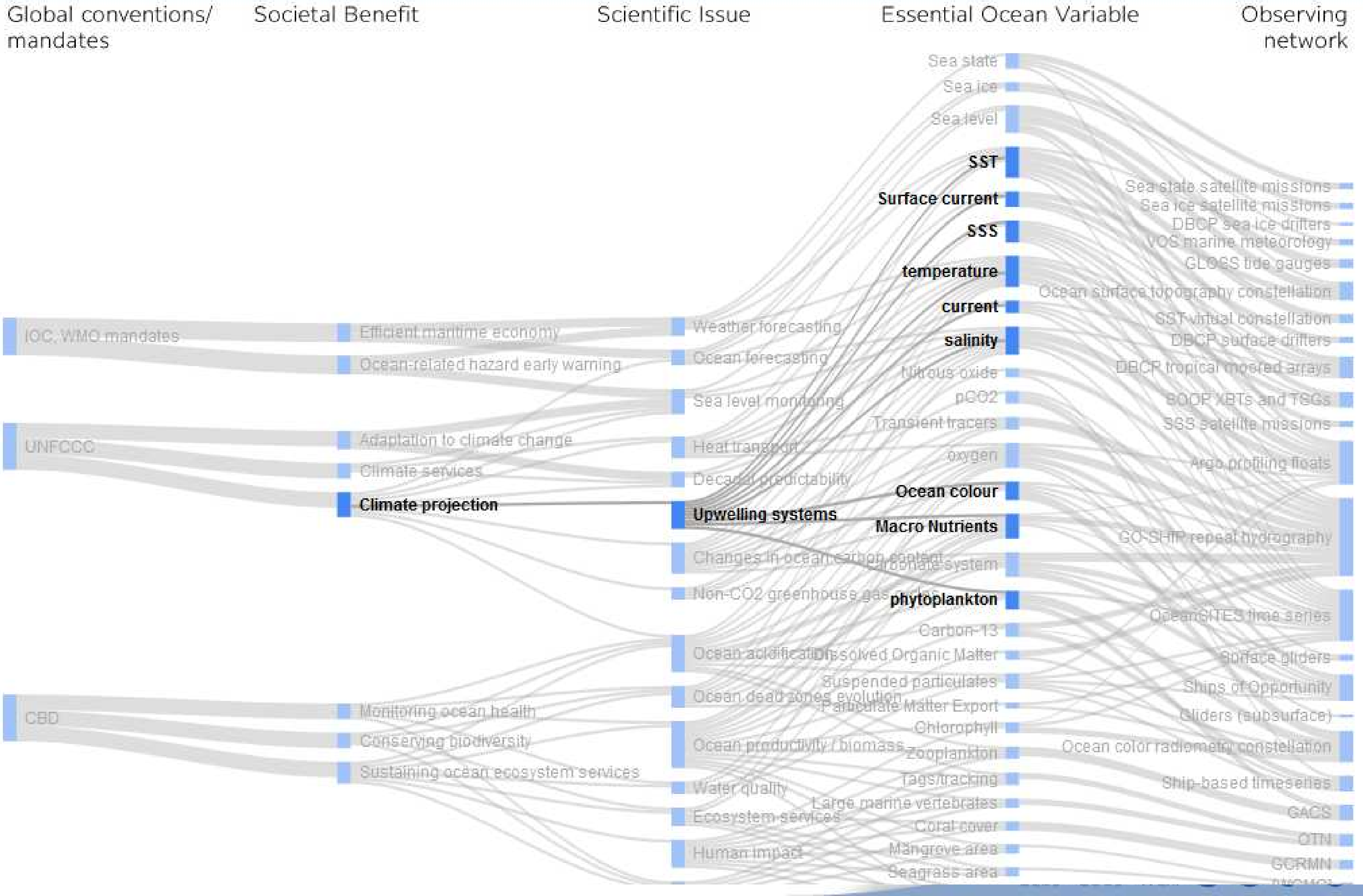
- **IOOS Physical Variables**:
  - **salinity**, **temperature**, bathymetry, **sea level**, surface waves, **surface (vector) currents**, **ice concentration**, **surface heat flux**, bottom characteristics
  - **IOOS Meteorological variables are covered by GCOS**
- **GOOS Physical Variables:**
  - Based on GCOS Ocean variables
- **Related GCOS Physical Variables:**
  - Surface: **Sea-surface temperature**, **Sea-surface salinity**, **Sea level**, **Sea state**, **Sea ice**, **Surface current**, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton.
  - Subsurface: **Temperature**, **Salinity**, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers
  - Atmospheric: temperature, humidity, pressure, **Rainfall**, **Photosyntheticly Active Radiation (PAR)**, and many others

GOOS Strategic Mapping

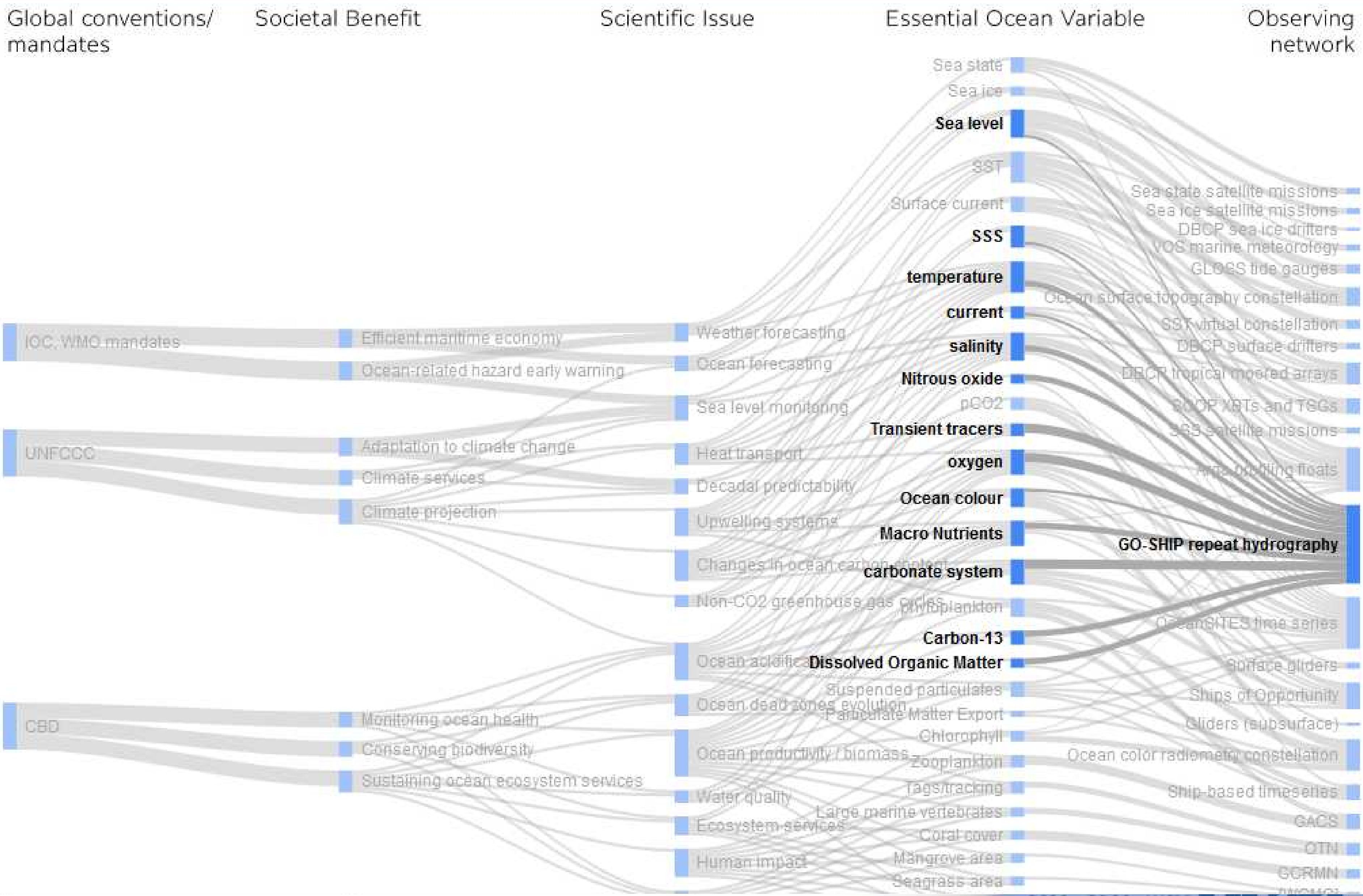
- http://lists-ioc-goos.org/goos-strategic-mapping-graphic



Links from Applications to EOVs



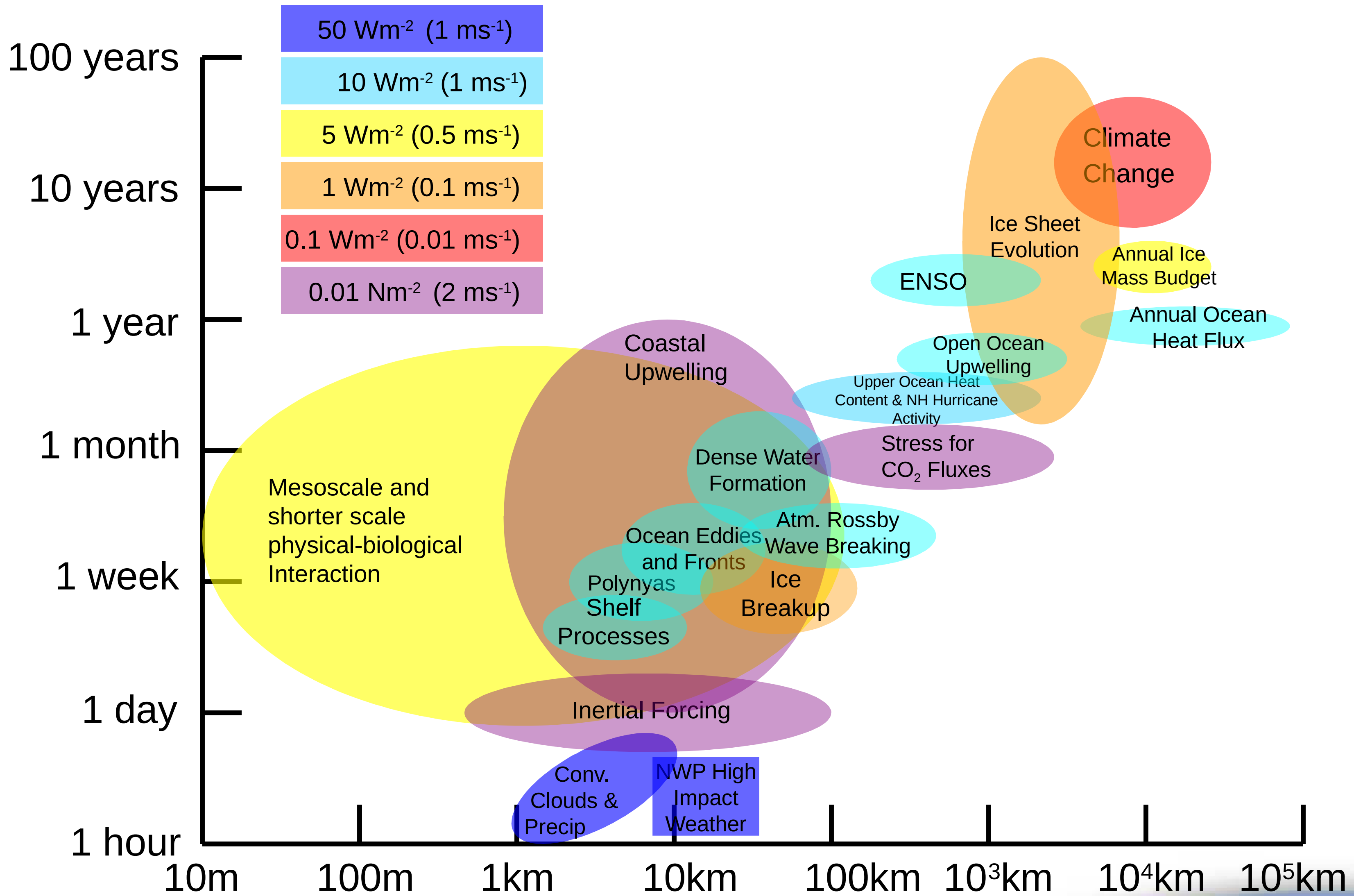
Observation Network Link to ECV



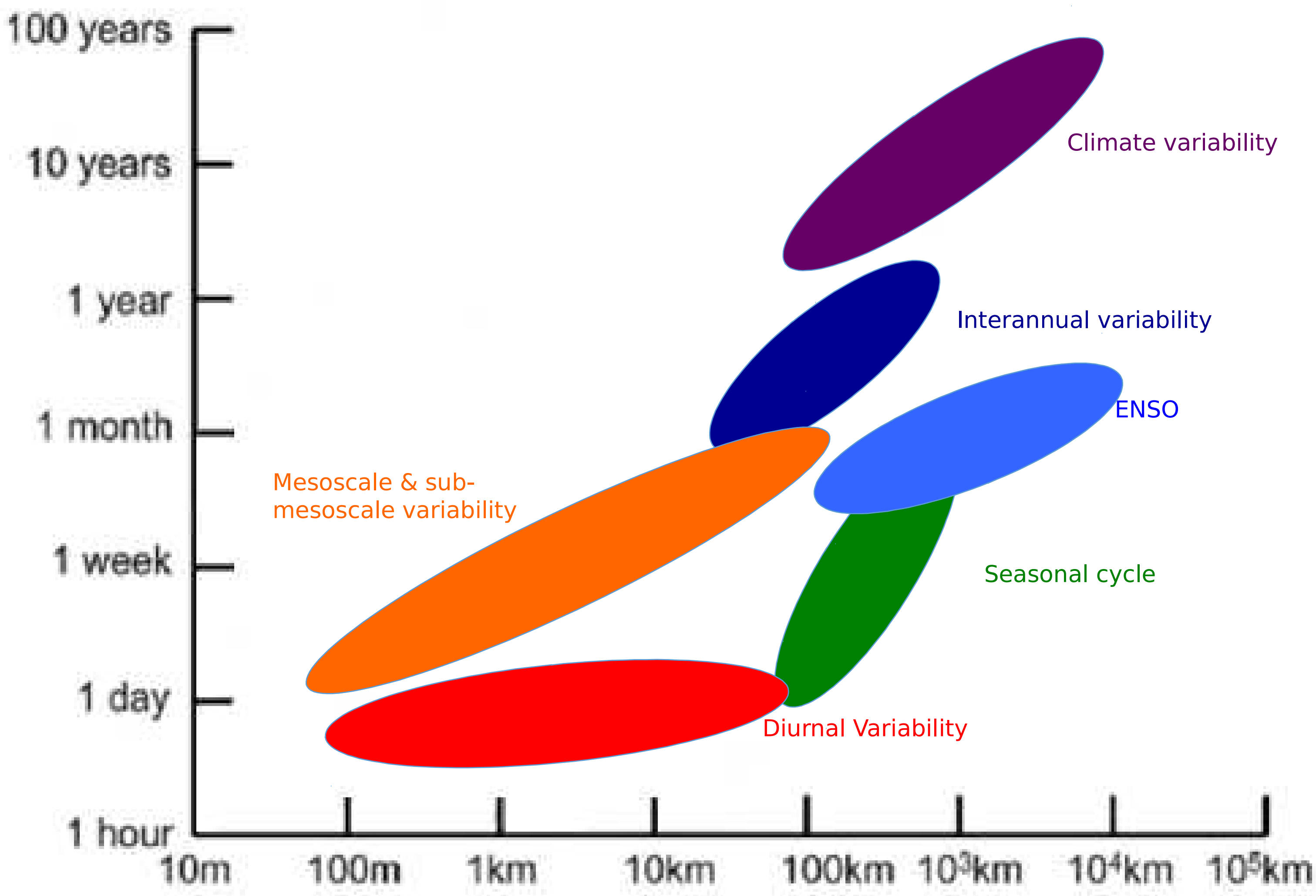
What I Need to Make the Case for Surface Fluxes

- Science issues
- Societal benefits
- Accuracy requirements
  - Bias
  - Random error (on a specific space and time scale, not per observation)
  - Sampling constraints
- A plan to achieve the above
  - If it is not feasible no sane agency will pay for it

Flux (and Wind Accuracies) Desired for Various Applications



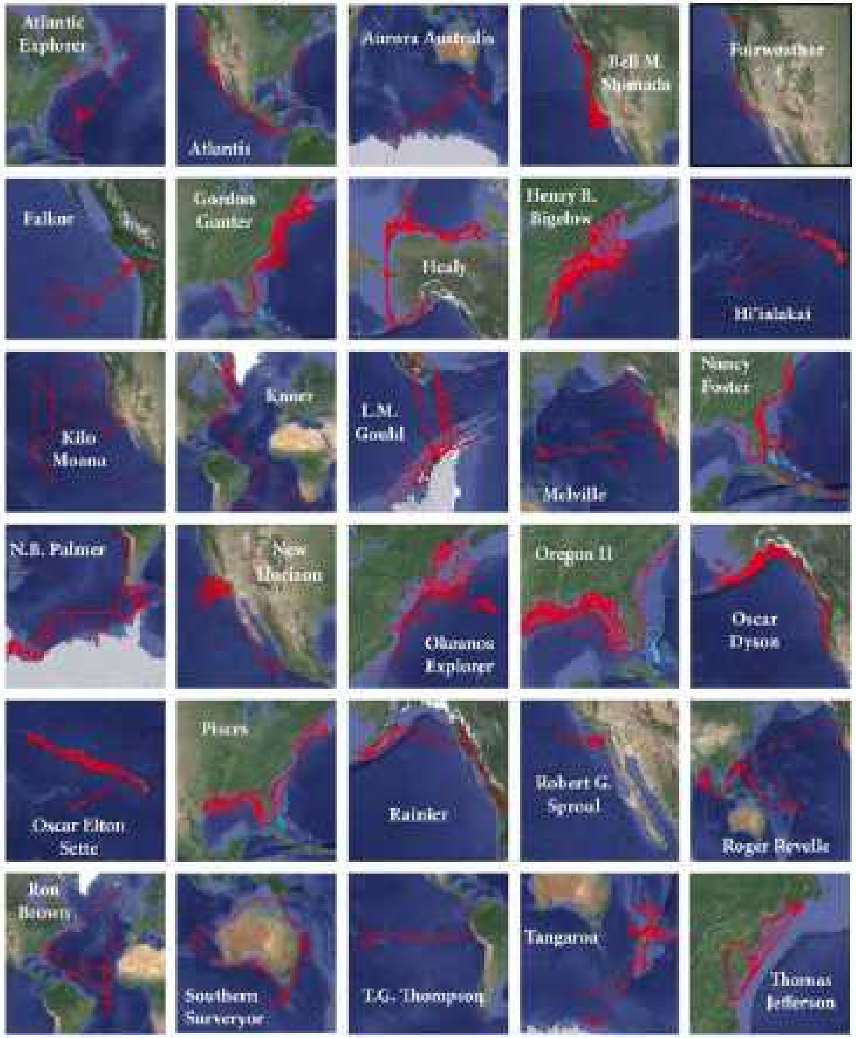
Surface Temperature Processes



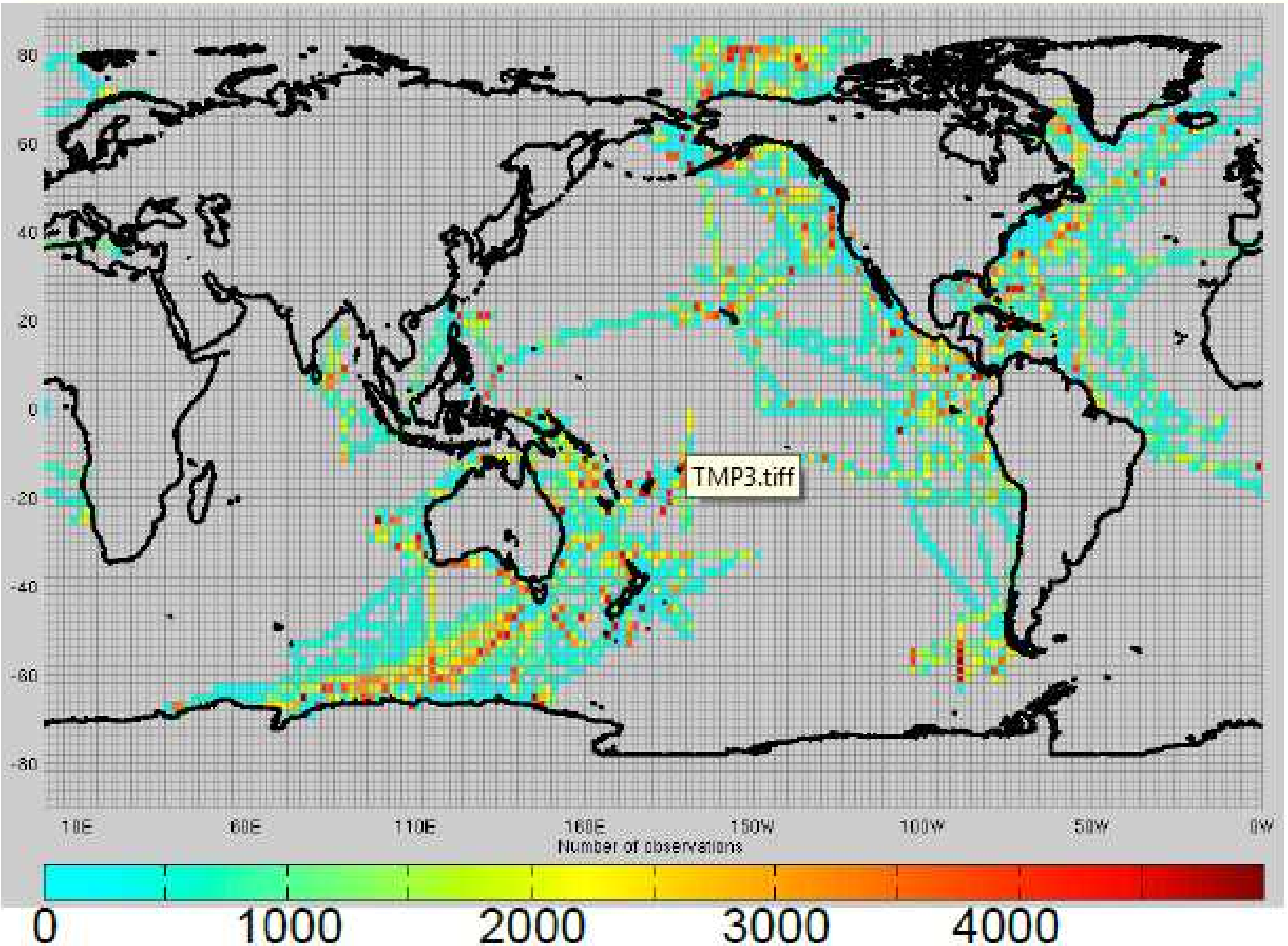
SAMOS Overview

- Routine collection and quality evaluation of underway meteorology and surface ocean data from research vessels (RV)
  - Position, course, speed, heading
  - Air temperature, humidity, winds, pressure, radiation, precipitation
  - Sea temp., salinity, conductivity
- Research instrumentation deployed by vessel operators
- Australia and New Zealand provide only data from non-U.S. RVs
- 30 active vessels in 2013
  - NOAA (14), USCG (1), NSF Polar Program (2), WHOI (2), BIOS(1), SIO (4), SOI (1), UW (1), UH (1), Australia (2), New Zealand (1)

Cruise maps for each vessel in 2013



Observation Density for Fluxes: 2005-today

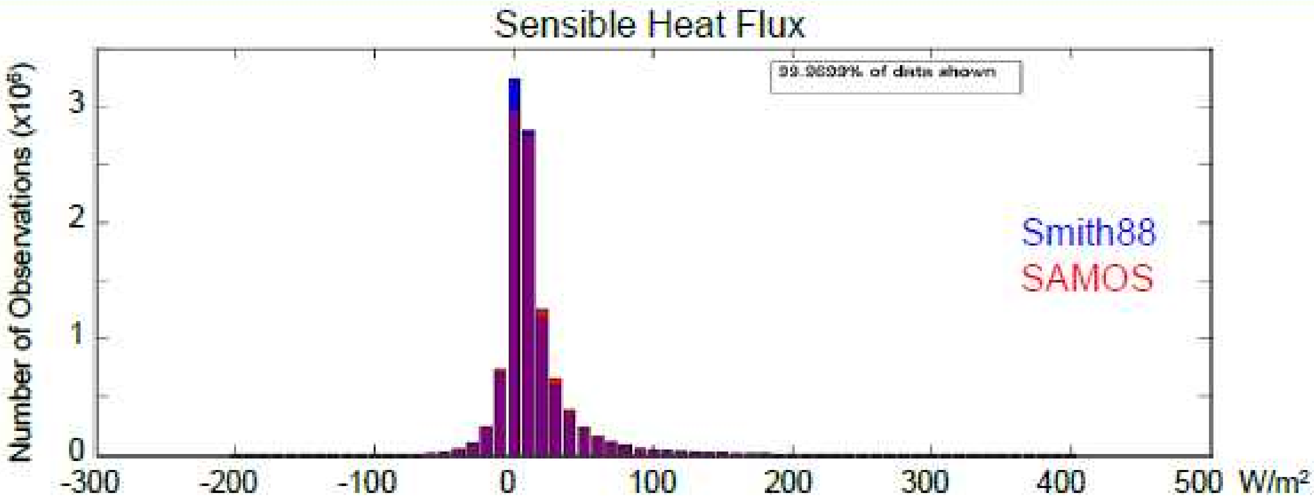


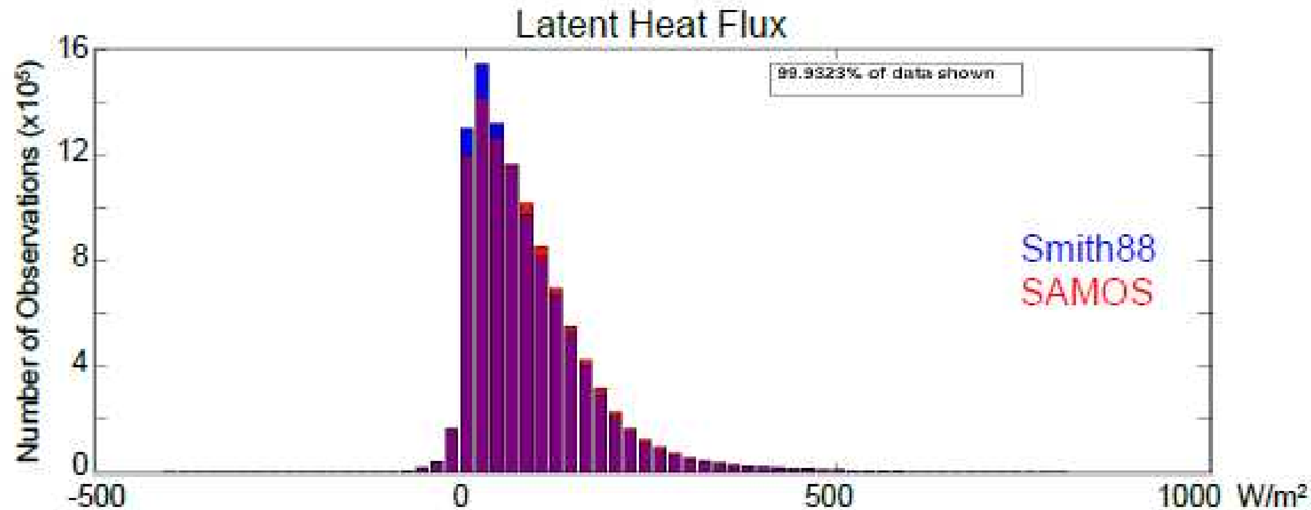
- Density of 1-minute records that include all values required for flux calculation
- Observations span latitudes, but low coverage in some basins

SAMOS Flux Overview

- Input
  - Air temperature, pressure, moisture value, wind speed, and sea temperature (measured at height of sensor)
- Selecting SAMOS observations
  - Input values must have known instrument heights
  - Exclude data not passing automated and/or visual quality control
- Algorithms
  - Smith et al. 1988, SAMOS variant of Bourassa (2006), and COARE 3.5
- Output
  - Latent and sensible heat flux; wind stress components; wind speed, specific humidity, and air temperature at 10 m; roughness length

Smith'88 vs. SAMOS Flux Distributions



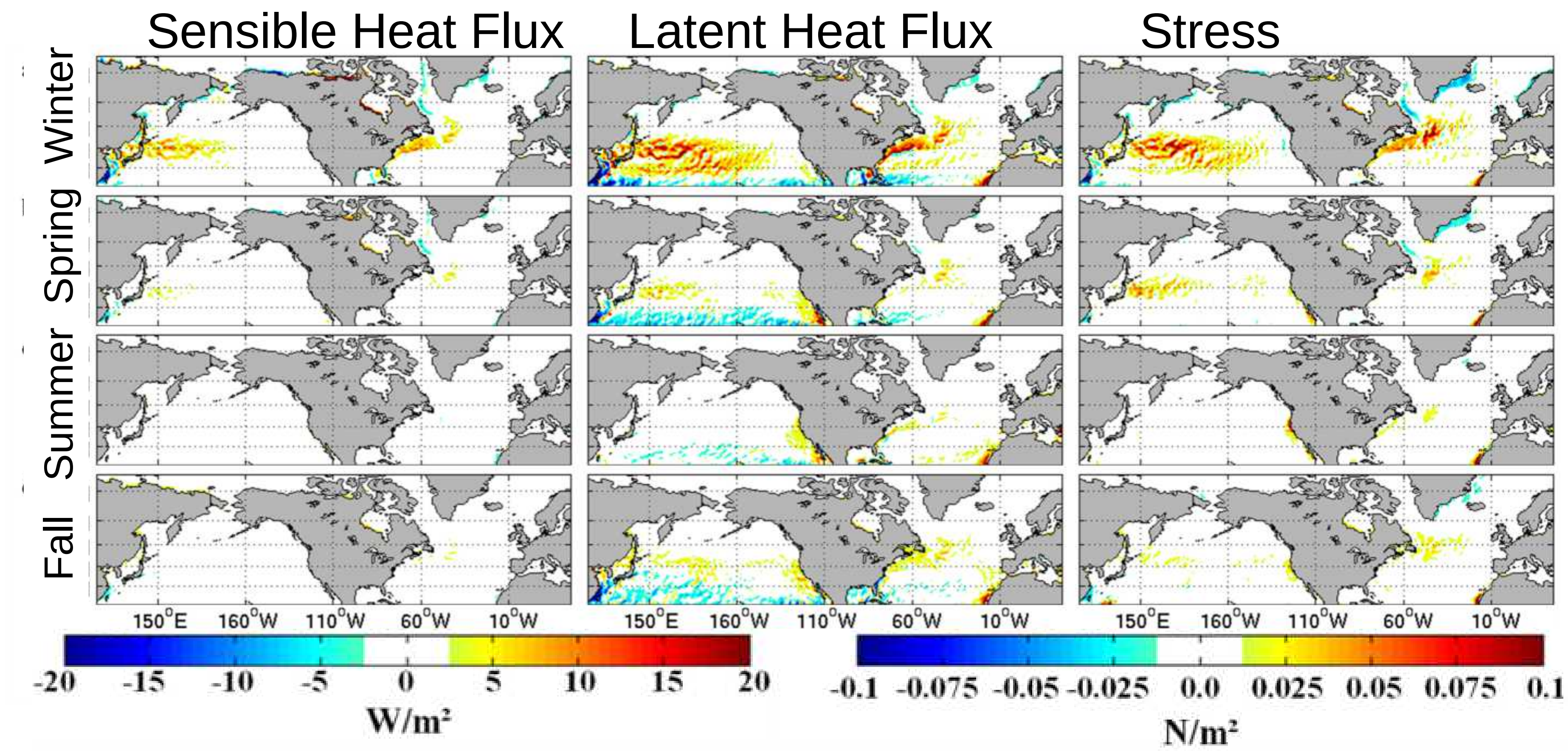


SAMOS

Shipboard Automated Meteorological and Oceanographic System

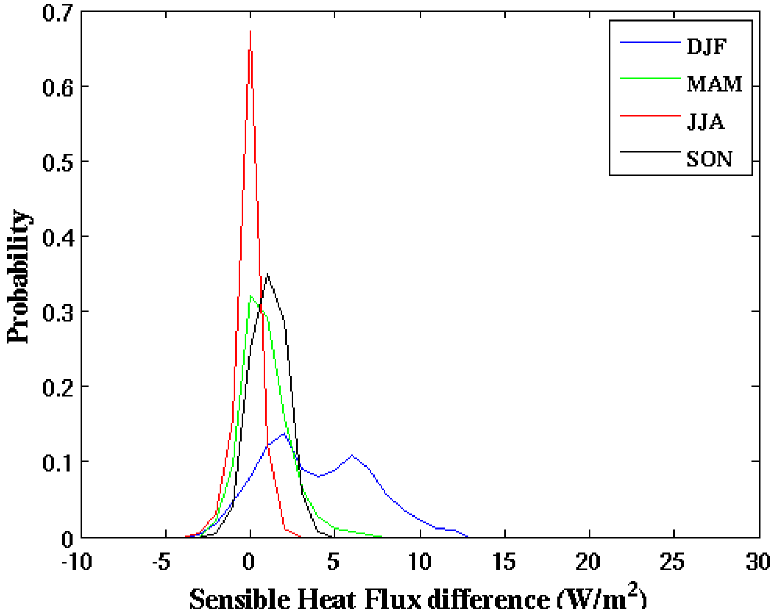
http://samos.coaps.fsu.edu

Seasonal Results

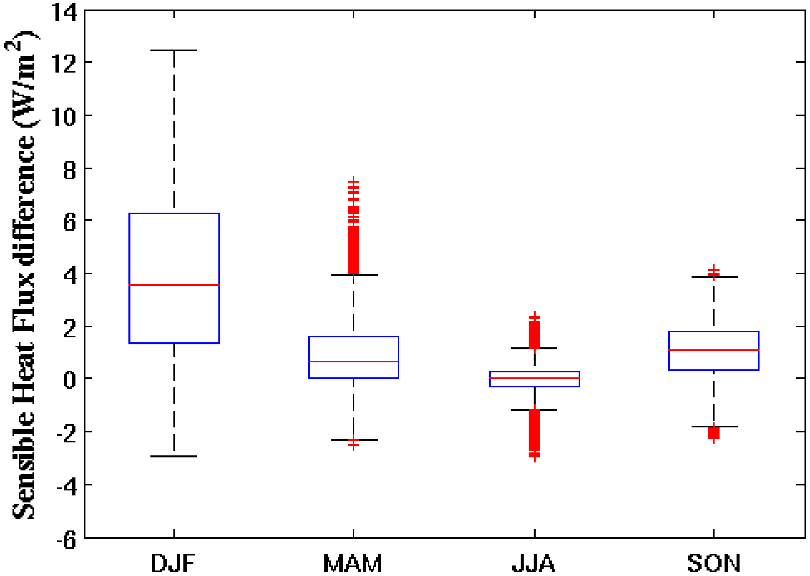


2002 – 2003 seasonal average differences in SHF (left), LHF (middle), and wind stress (right) for DJF (top row), MAM (2nd row), JJA (3rd row), and SON (bottom row)

Seasonal SHF



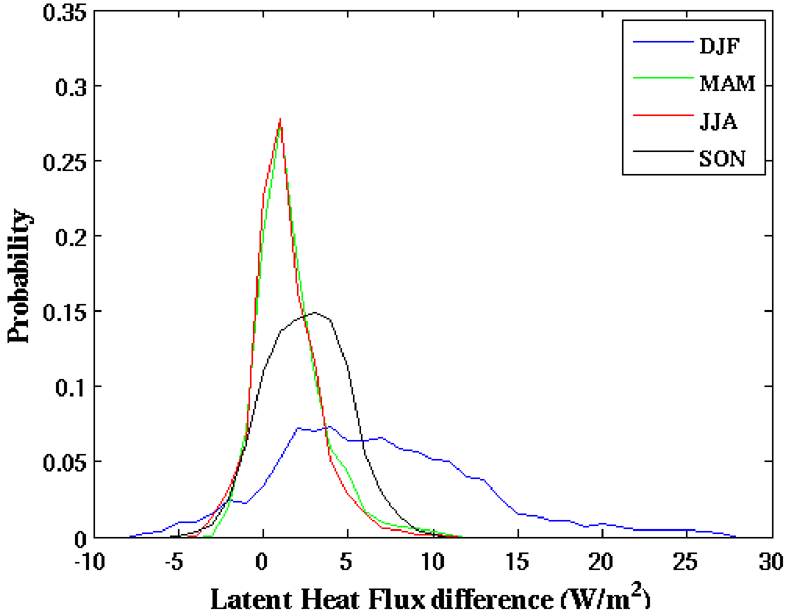
2002-2003 **seasonal PDF's of SHF** difference over the Gulf Stream



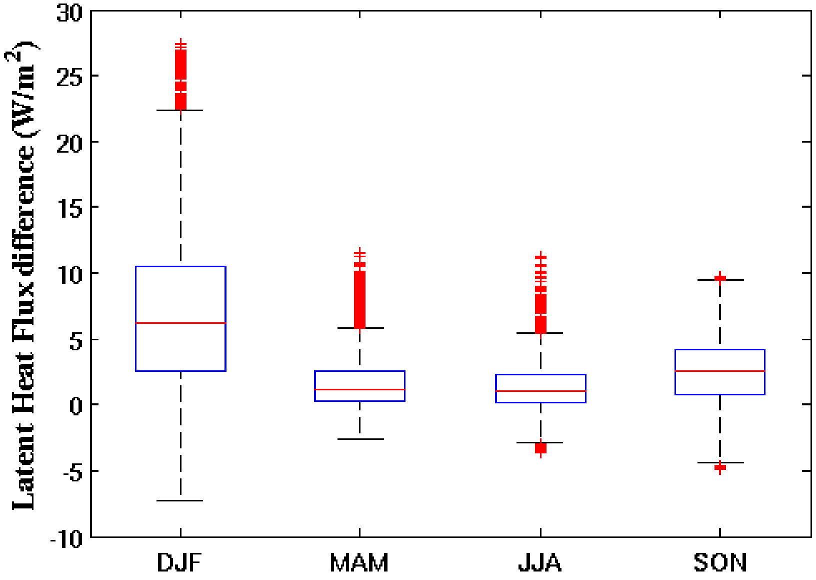
2002-2003 **seasonal box plots of SHF** difference over the Gulf Stream

PDFs show seasonally averaged values from each grid point in the domain

Seasonal LHF



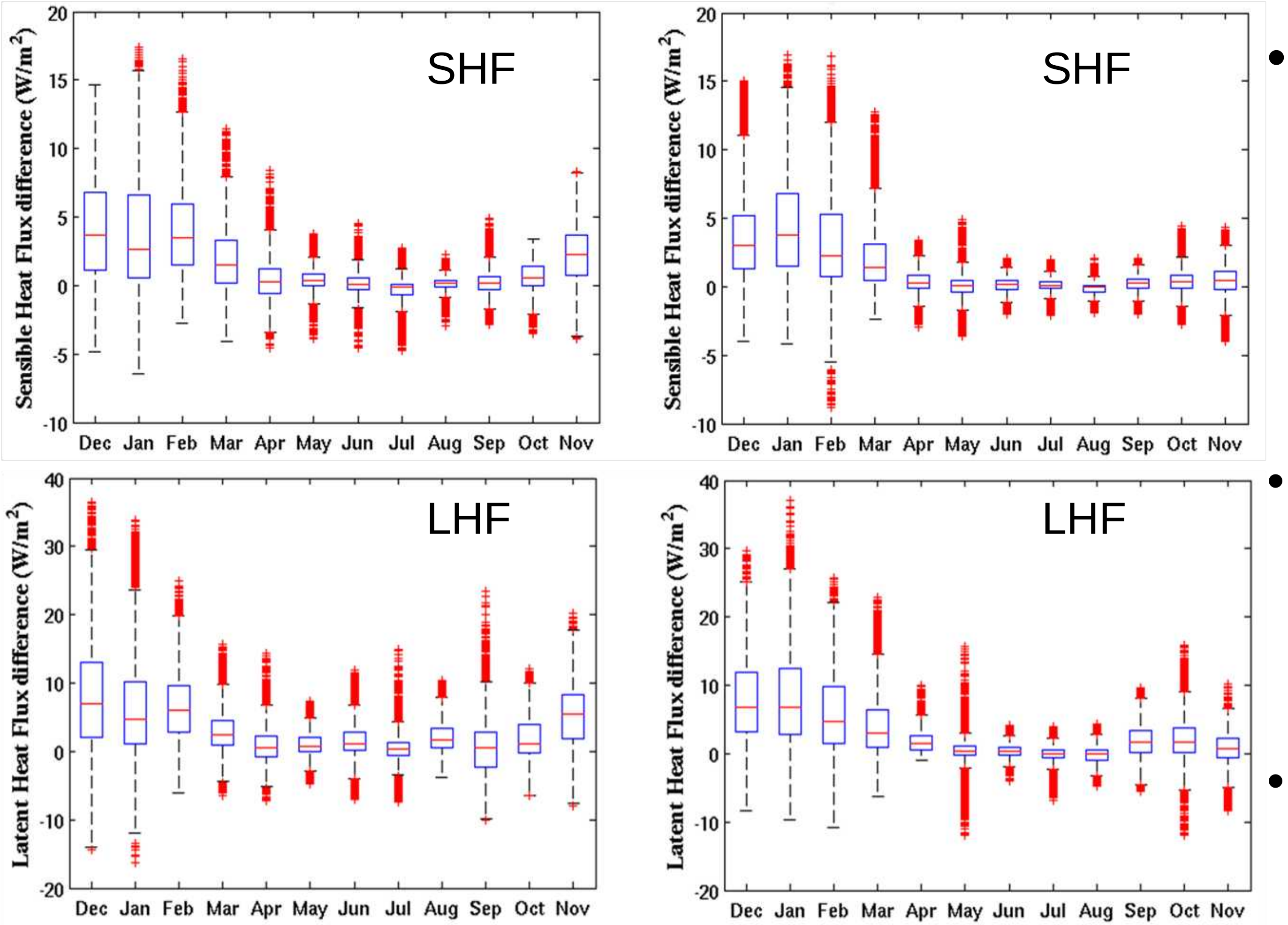
2002-2003 seasonal PDF's of **LHF difference** over the Gulf Stream



2002-2003 seasonal box plots of **LHF difference** over the Gulf Stream

PDFs show seasonally averaged values from each grid point in the domain

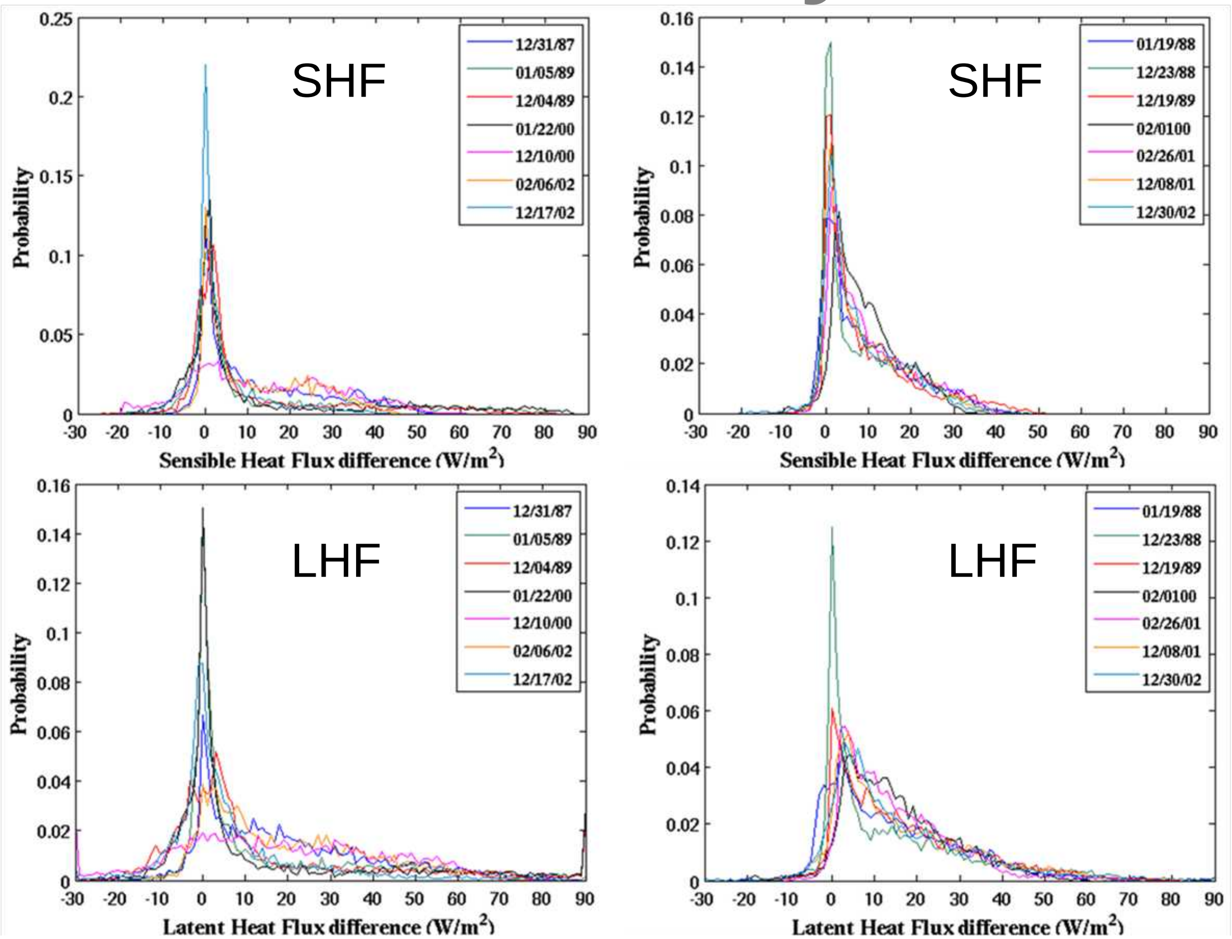
Monthly Box Plots



Dec. 2002 – Nov. 2003 monthly box plots of SHF (top) and LHF (bottom) difference over the Gulf Stream (left) and Kuroshio Extension (right)

- Monthly averaged turbulent flux differences are more sensitive to the background environment
- More spatial variability than seasonal averages
- Annual cycle is better resolved

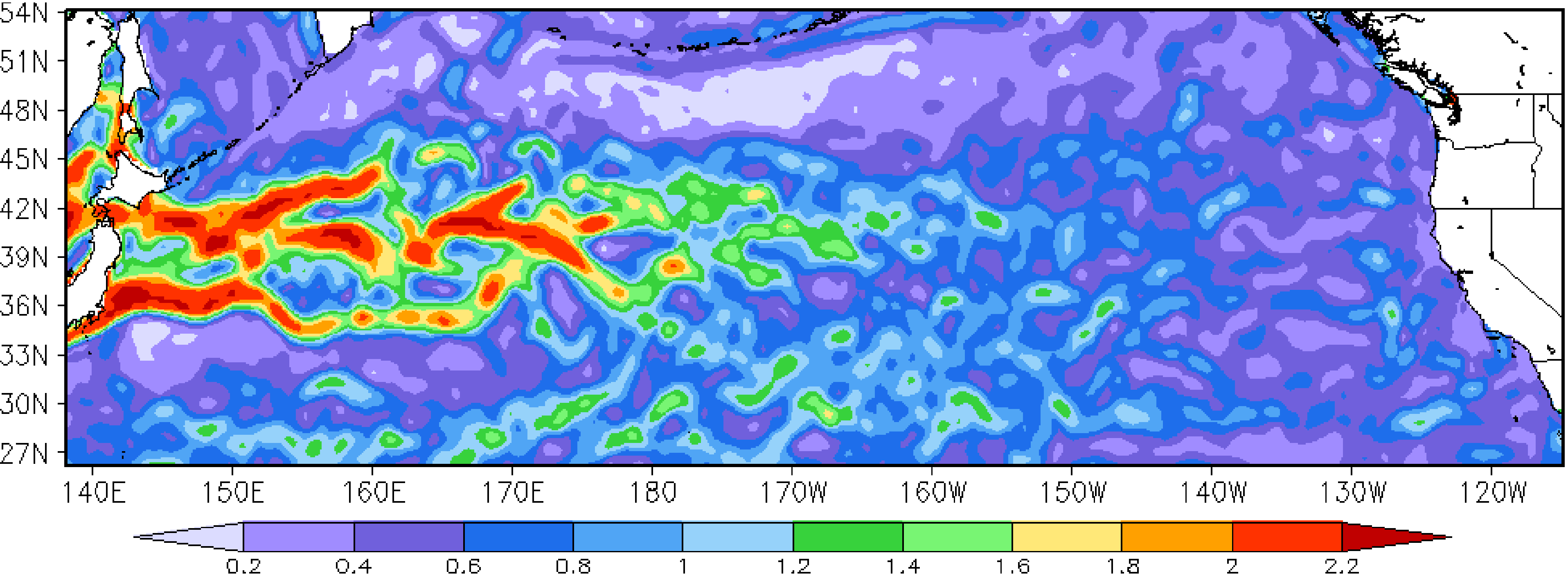
Daily Results



Daily PDF's of SHF (top) and LHF (bottom) difference over the Gulf Stream (left) and Kuroshio Extension (right) during selected high wind events

- Snapshots in the life cycle of individual synoptic-scale events that can impact storm evolution and upper oceanic properties
- Despite the same physical process taking place over the Gulf Stream and Kuroshio Extension, PDF shapes are different

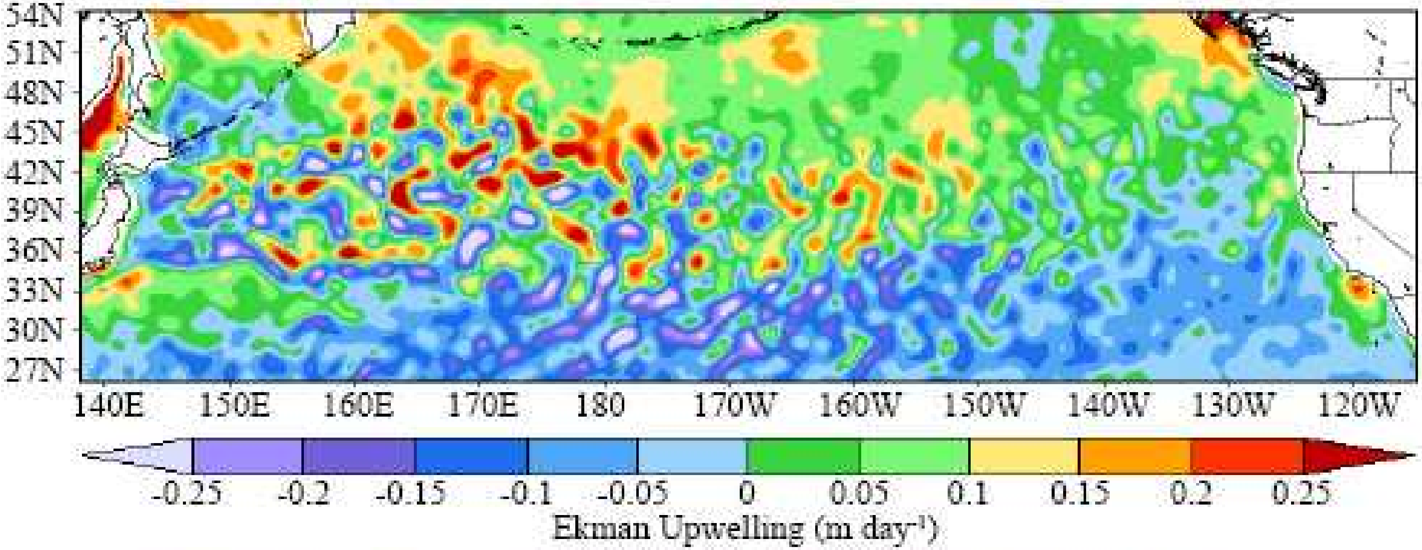
SST Gradients For Upwelling Example



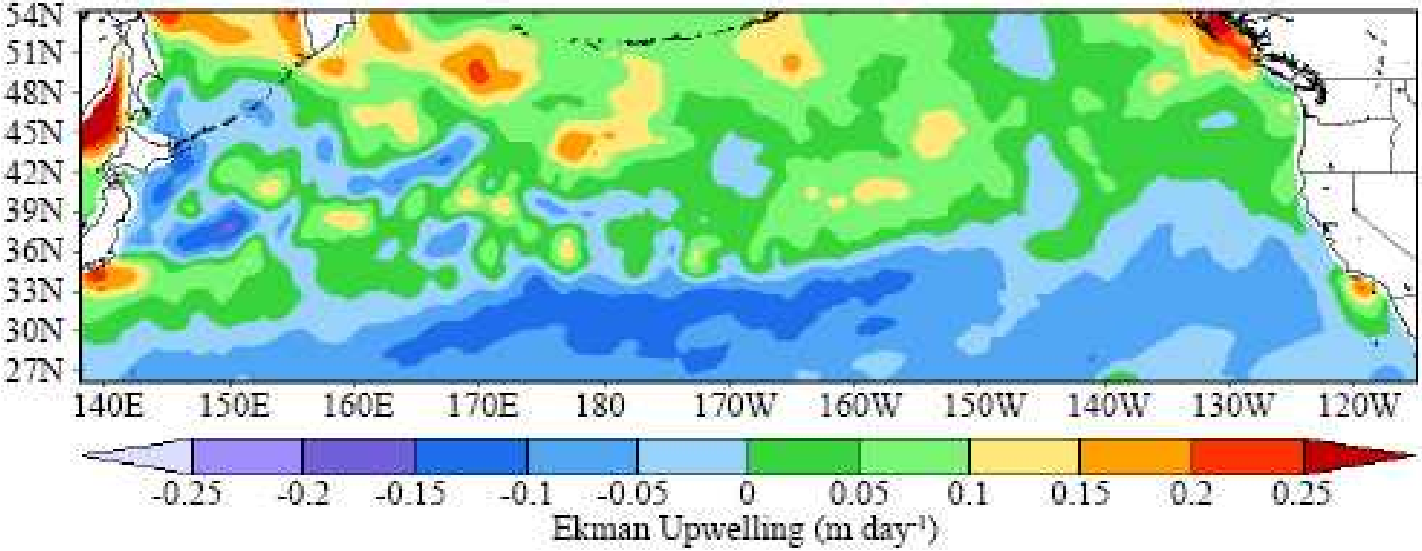
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2°C/100km

- There are substantial SST gradients over most of the ocean

Ekman Upwelling

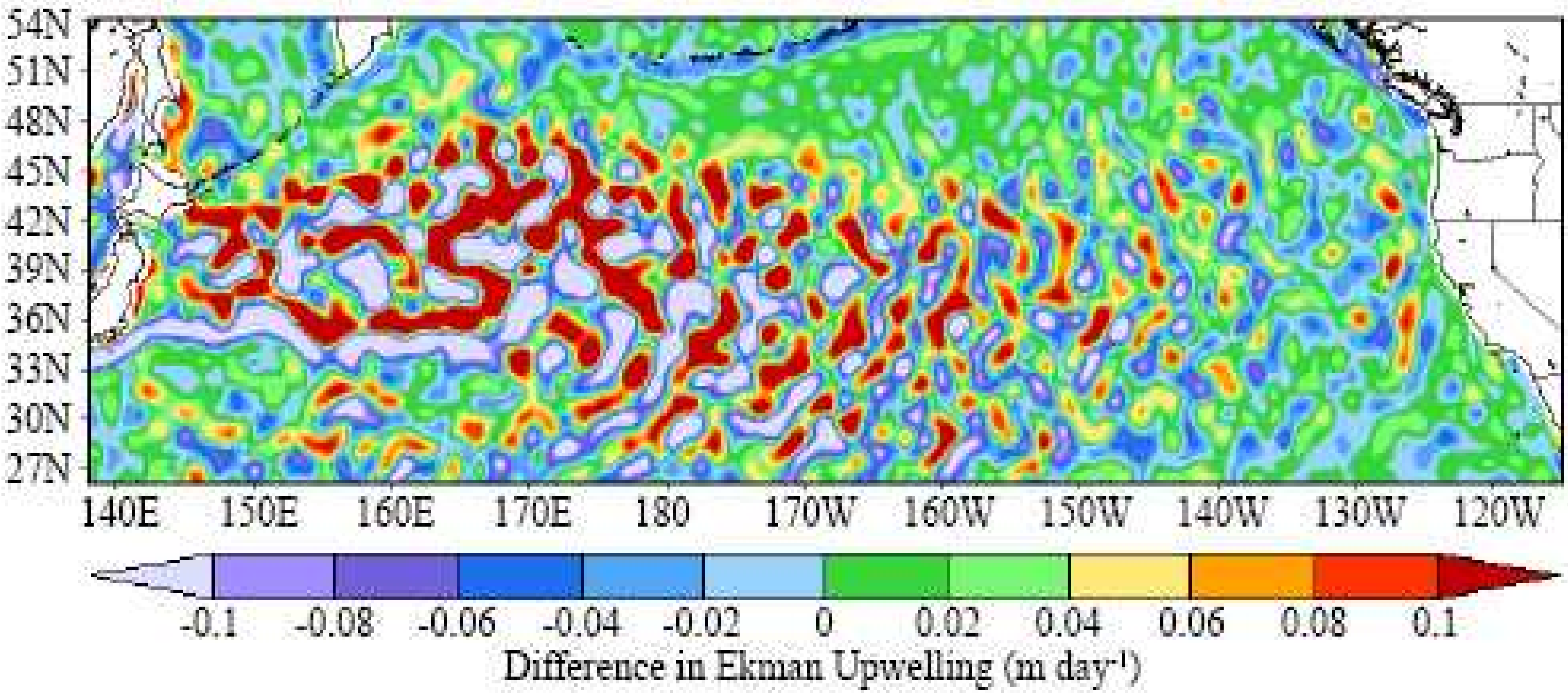


Baroclinic



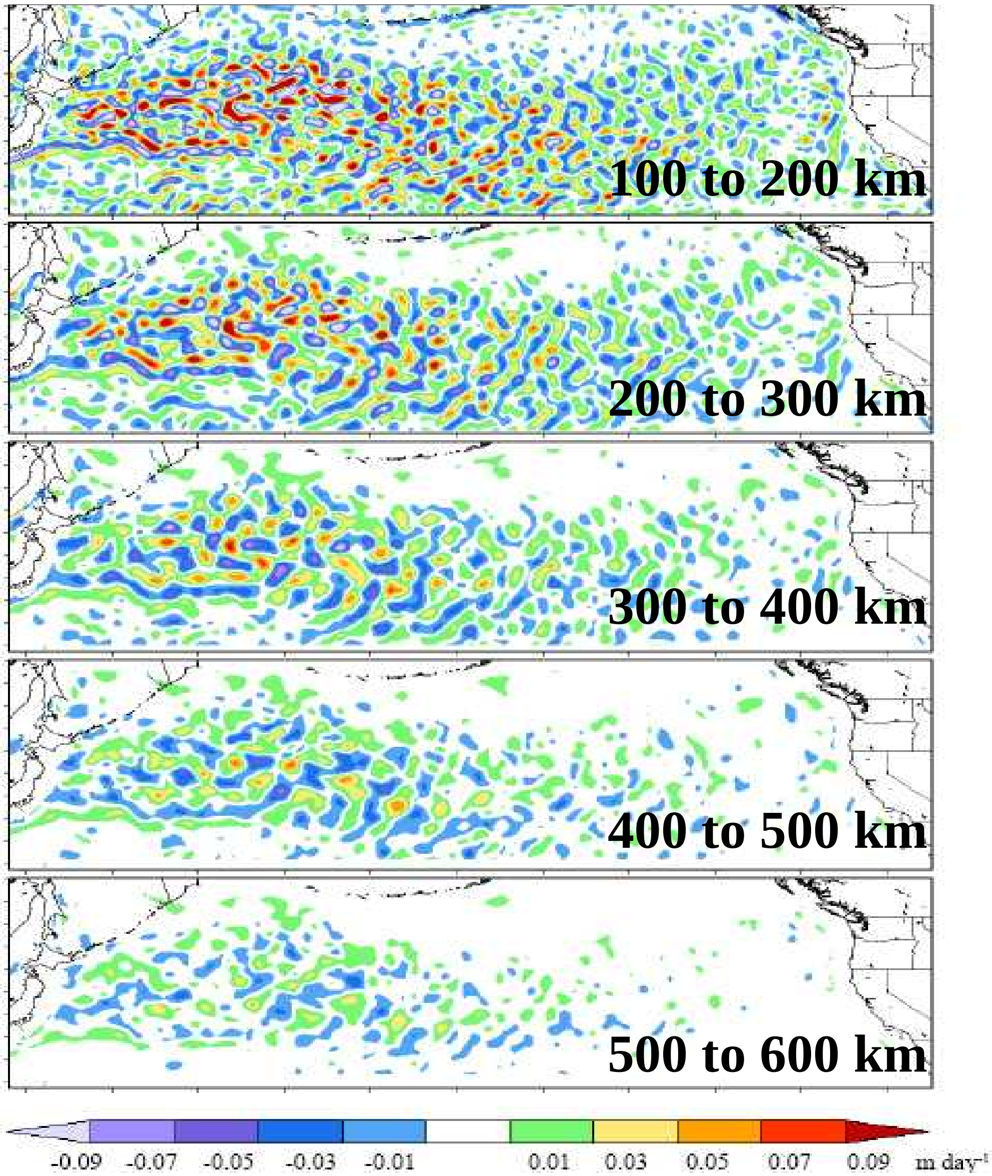
Control

Ekman Upwelling Changes



- Changes in Ekman Upwelling (Baroclinic case – control)
  - These are an order (1) impact
  - Many areas with >30% changes

Spatially Band-Pass Filtered Changes



- Biggest changes are on scale s poorly captured in weather models
- Need finer resolution models with better boundary-layers
- Note that spatial scale of up welling areas is smaller than that of downwelling events
- We need to couple models o n ‘fine’ spatial scales