Applications of Satellite Surface Vector Winds *(SVW)* in Models and Syntheses of Tropcial and Sub-Tropical Atmosphere-Ocean Interactions

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Four *(loosely connected)* Sub-Projects:

- Mesoscale Convective System *(MCS)* Detection;

  a multi-platform evaluation of SVW signals (i.e. convergence and divergence) that correlate with MCS development and rain events.
  Brian Mapes and David Long; consultants.

- SVW Cross-Validation in Hurricanes;

  comparisons of satellite SVW (wind and rain) retrievals with in-situ ocean drifters deployed in developing TC systems of the sub-tropical N. Atlantic.
  David Long; consultant. Peter Niiler, Thomas Bengtsson; collaborators.

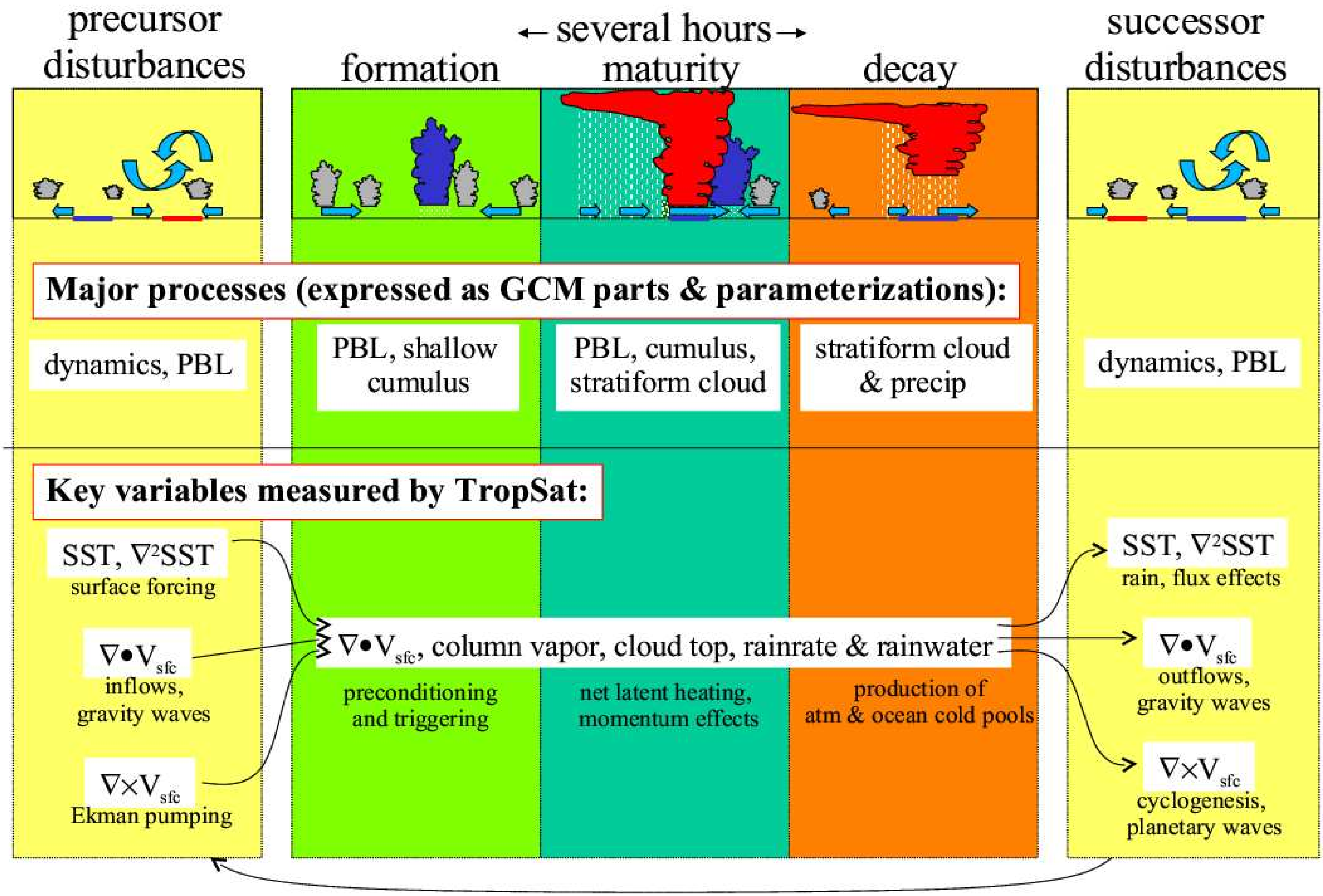
- *[SVW]* 4DVAR in the Intra-Americas Seas *(IAS)*;

  exploit *[SVW]* to guide ocean model 4DVAR assimilation and forecasts in the IAS
  A. Moore (and IAS ROMS team); collaborators.

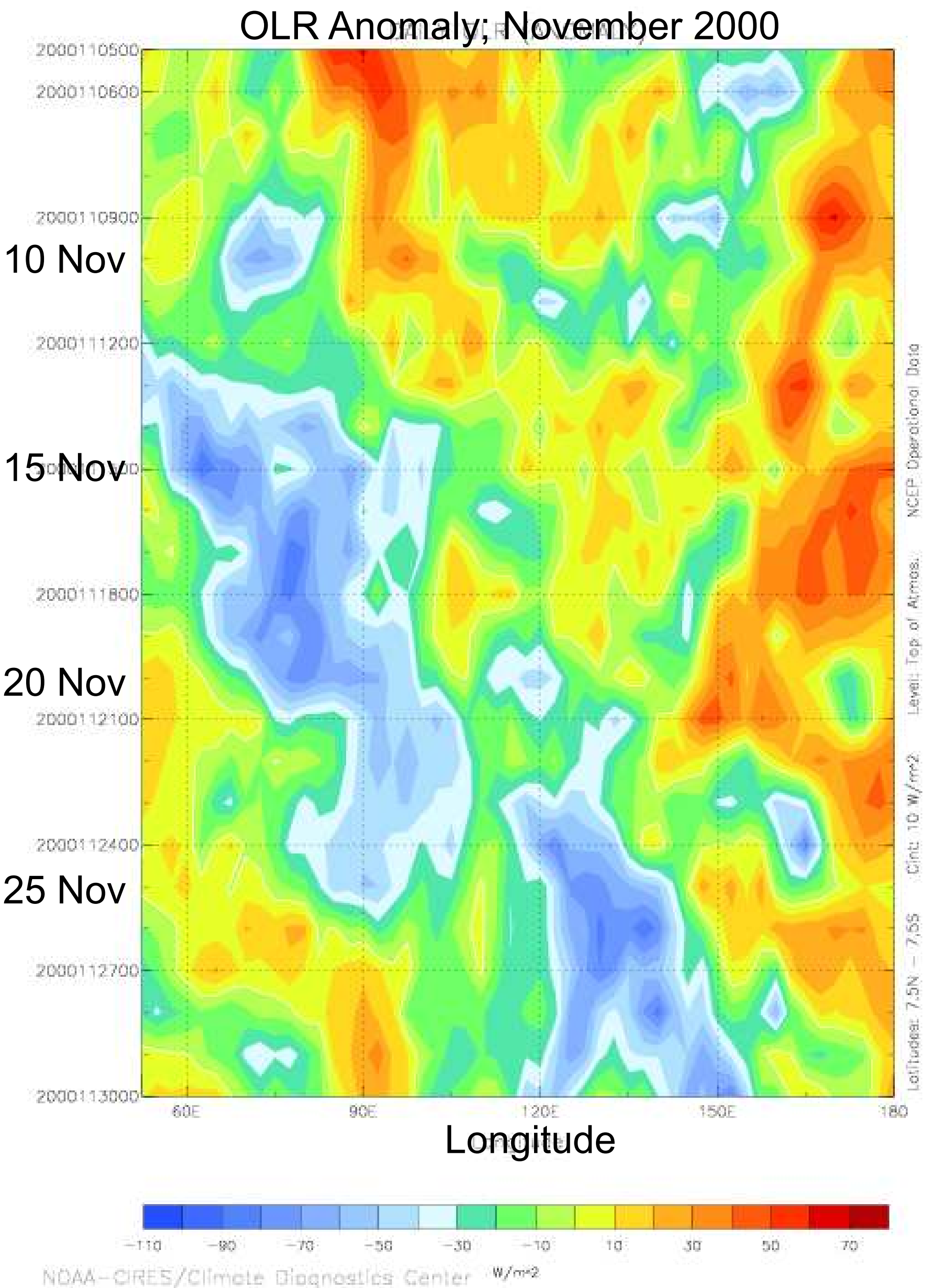
- *[SVW]* and Ocean General Circulation Model *(OGCM)* Uncertainty;

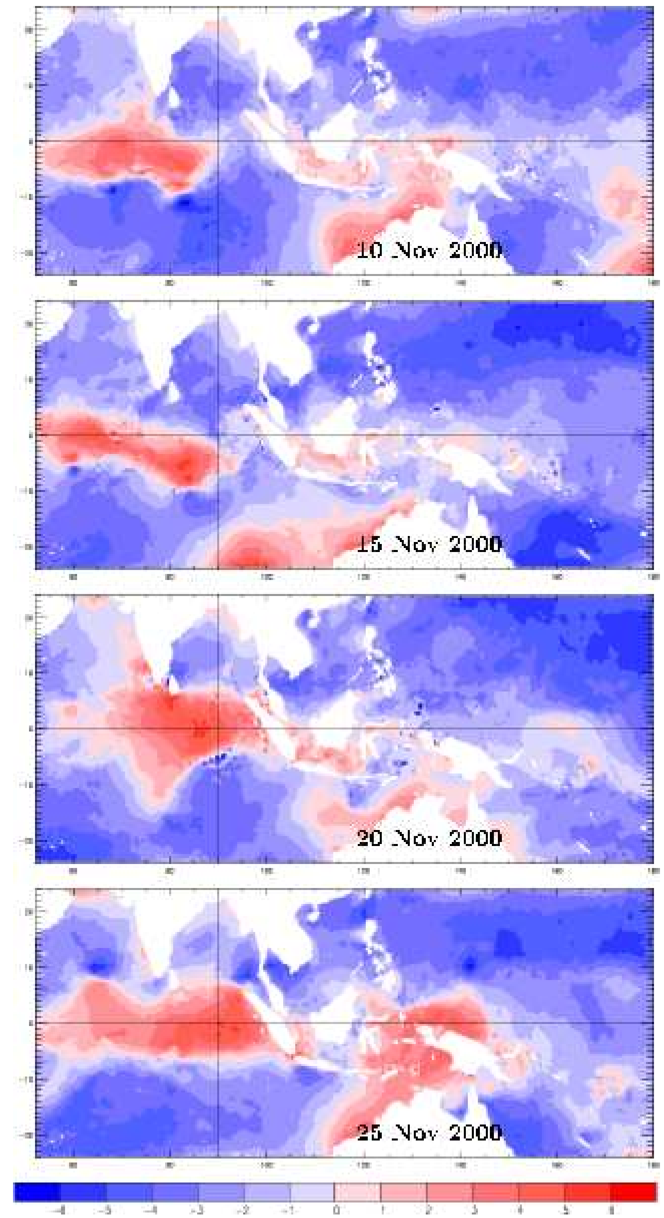
  OGCM uncertainty quantification in global and regional simulations.
  Bill Large and Gokhan Danabasoglu; collaborators.

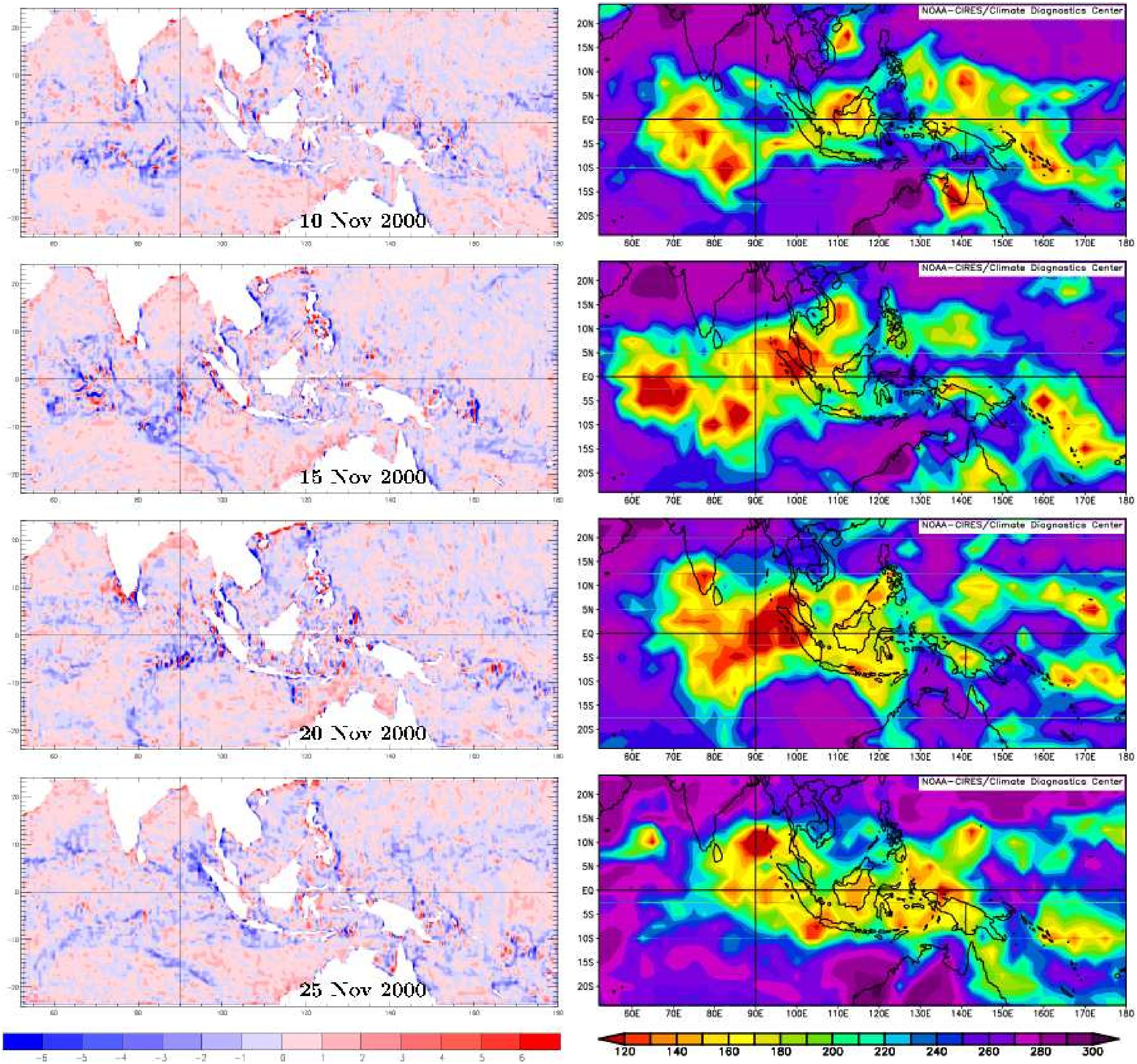
The Mesoscale Convective System (MCS) life cycle



Zonal Wind *Posterior Mean Fields* for a Single MJO Event







<u>Surface Convergence</u>
and
<u>Atmospheric Deep Convection</u>

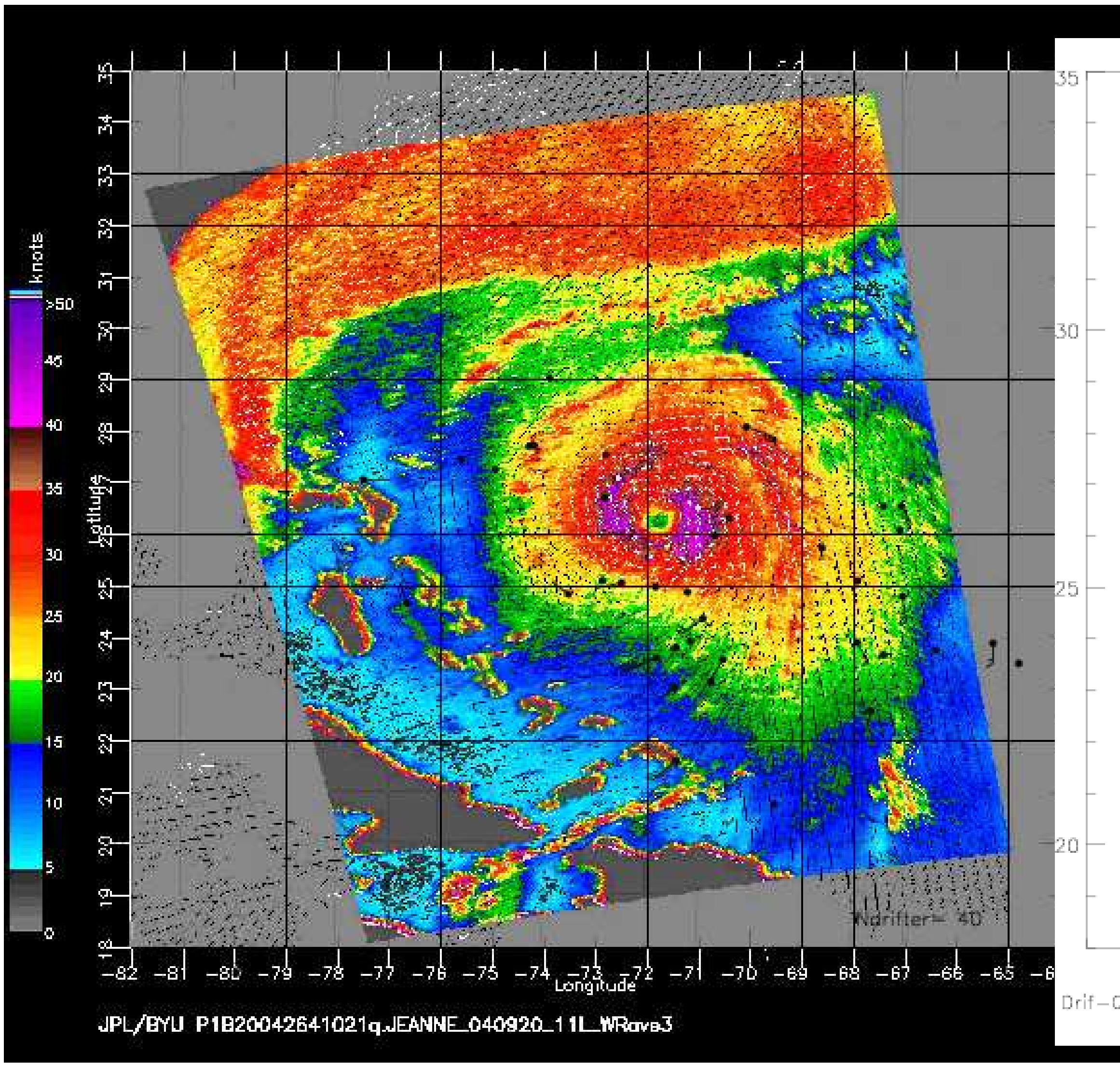
left panel:
daily composite convergence *(blue)* and divergence *(red)*

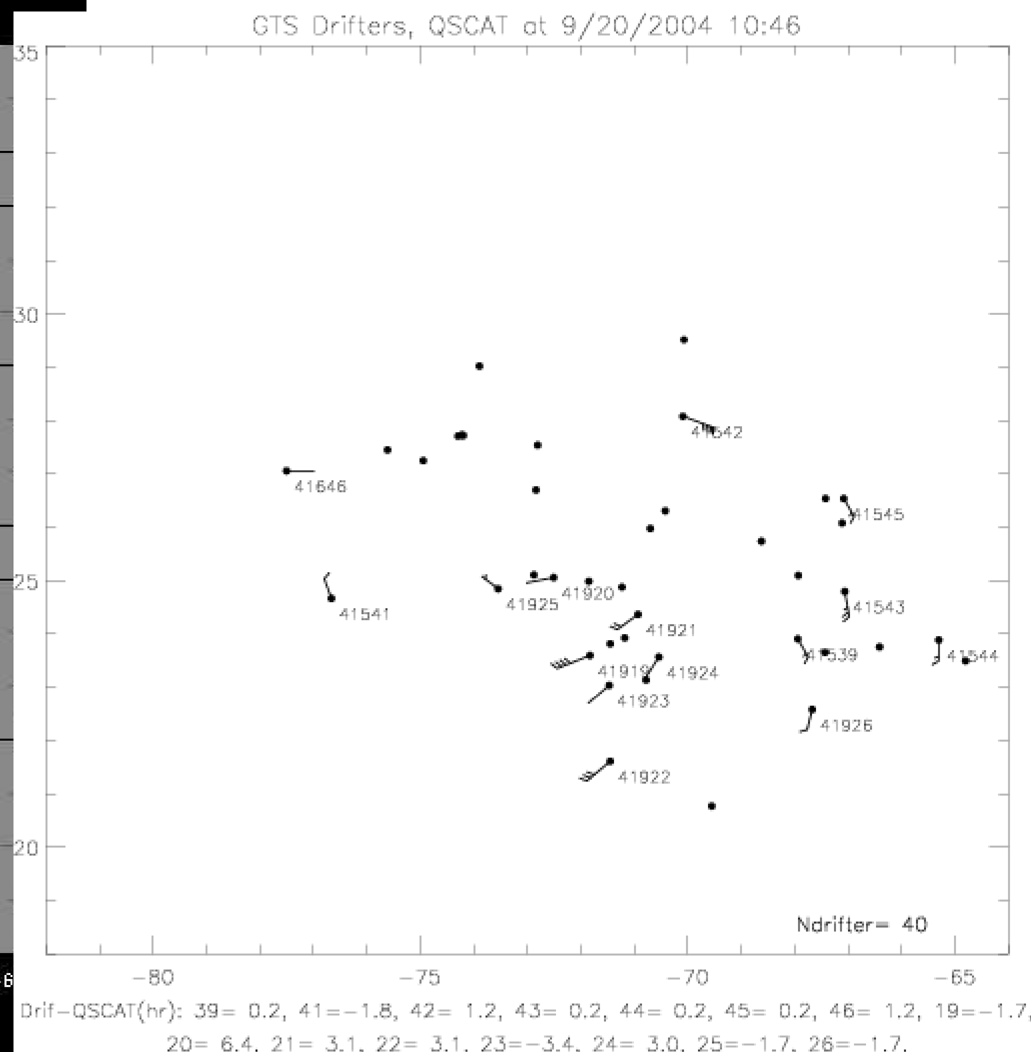
right panel:
daily average OLR
(red → deep conv)

SVW Cross-Validation in Hurricanes:

Ultra-high resolution wind (and rain) retrievals vs. Minimet and other drifters

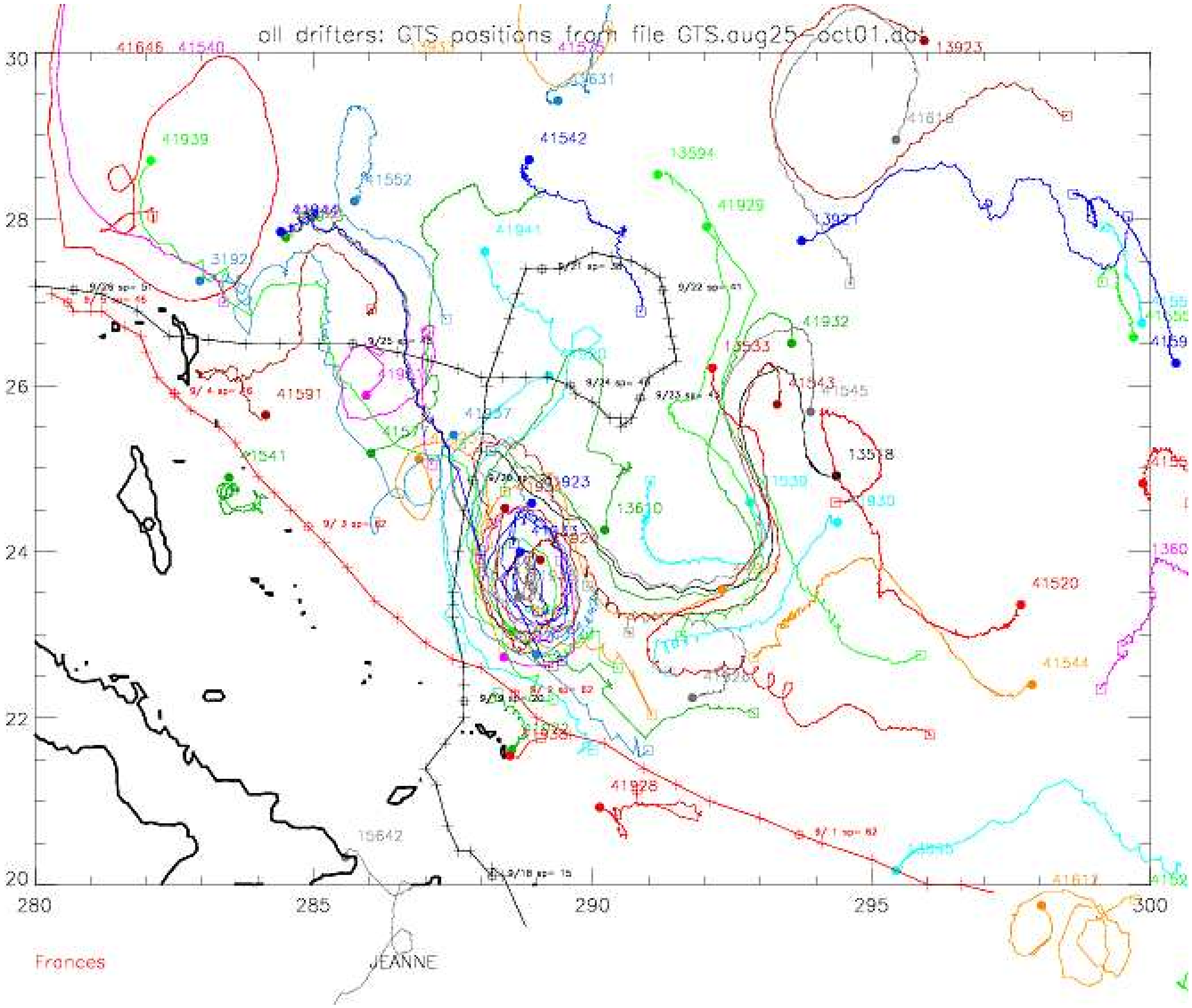
Estimate drag coefficient functional form (and uncertainty) in hurricane winds





Ocean Drifter Dataset:2004 Hurricane Season, NW Atlantic

Air-Sea Bayesian Hierarchical Model

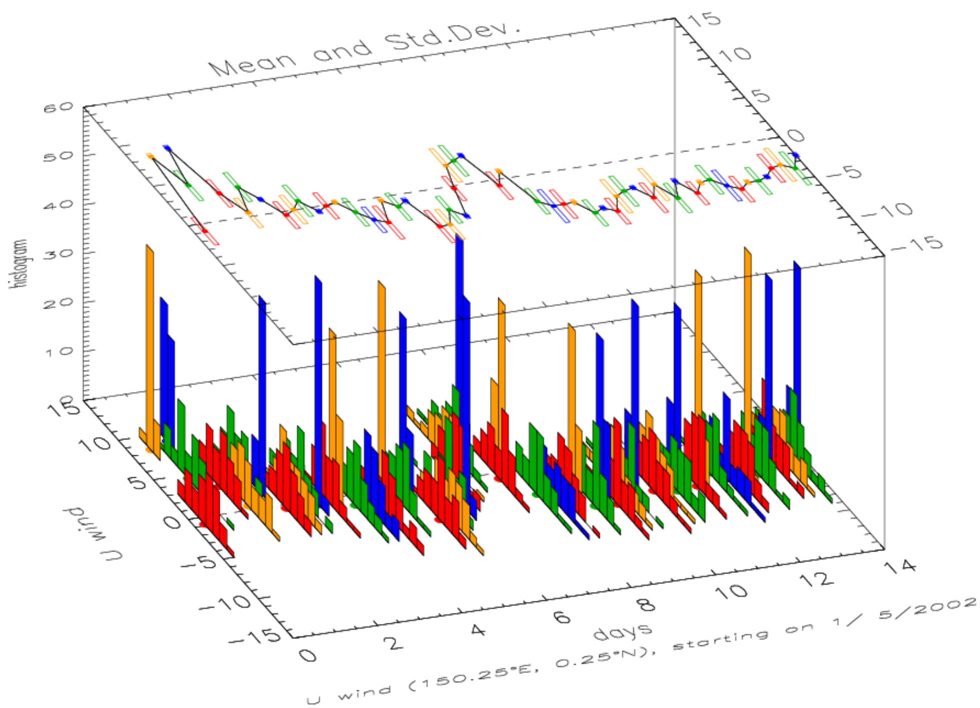


Milliff et al. (2003) JTech; Bengtsson et al. (2005) JGR

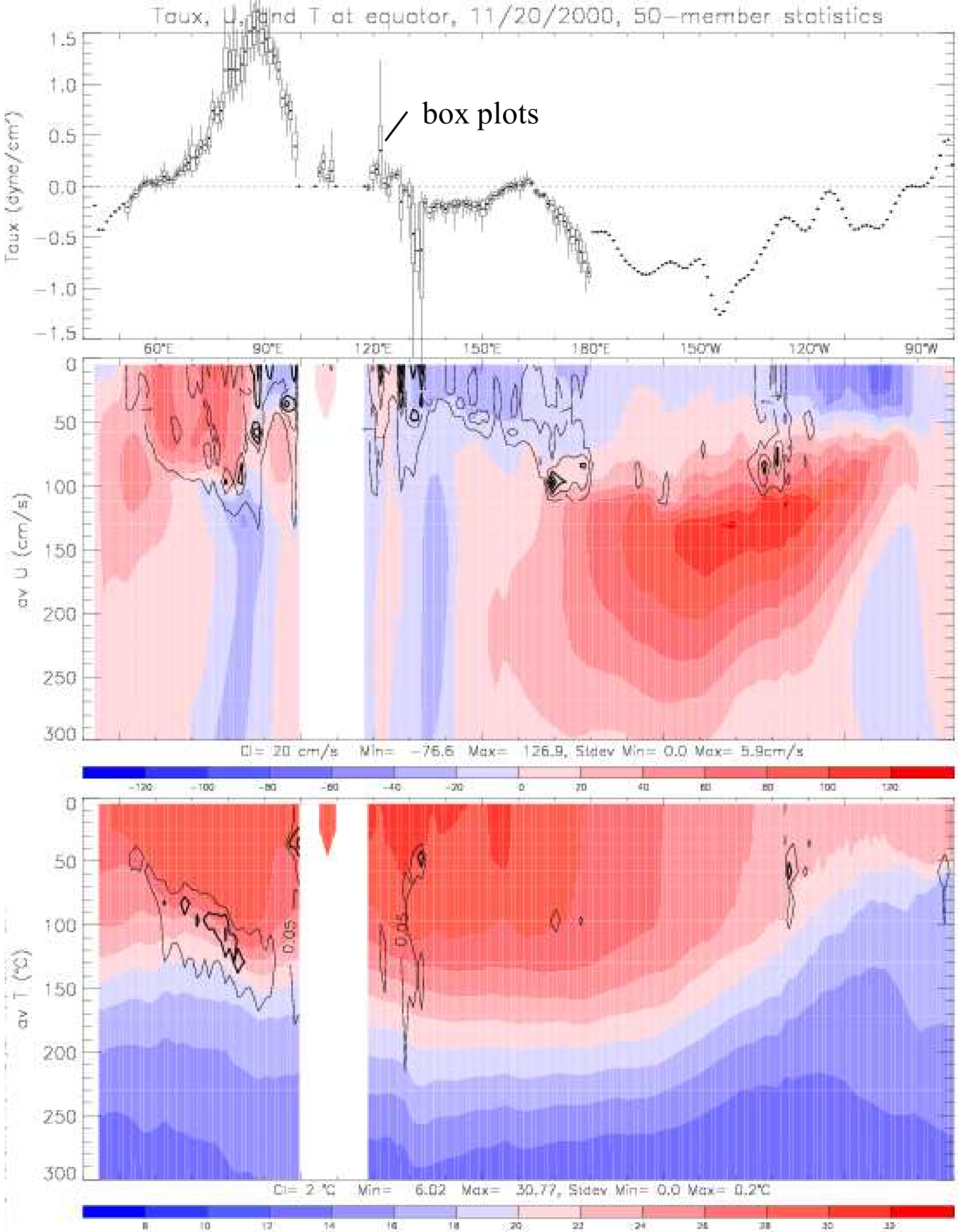
Ocean General Circulation Model (OGCM) and Ocean Forecast Model Applications of [SVW] from Bayesian Hierarchical Models (BHM)

Use SVW abundance and precision, and precisely characterized uncertainty, to deduce and distribute ocean model uncertainties (less well known)

- *OGCM Uncertainty Distribution (review)*
  CCSM Ocean Model Component response to [SVW] forcing during an MJO
- *Variational DA*
  Regional Ocean Model System (ROMS) 4DVAR in Intra-Americas Seas (IAS)
- *Sequential DA*
  Mediterranean Forecast System (MFS) Kalman Filter and Ensemble Initial Conditions



20 Nov; Zonal Velocity and Temperature Equatorial Sections



$\tau_x(x)$

50-member ensemble winds (mean, standard deviation, range)

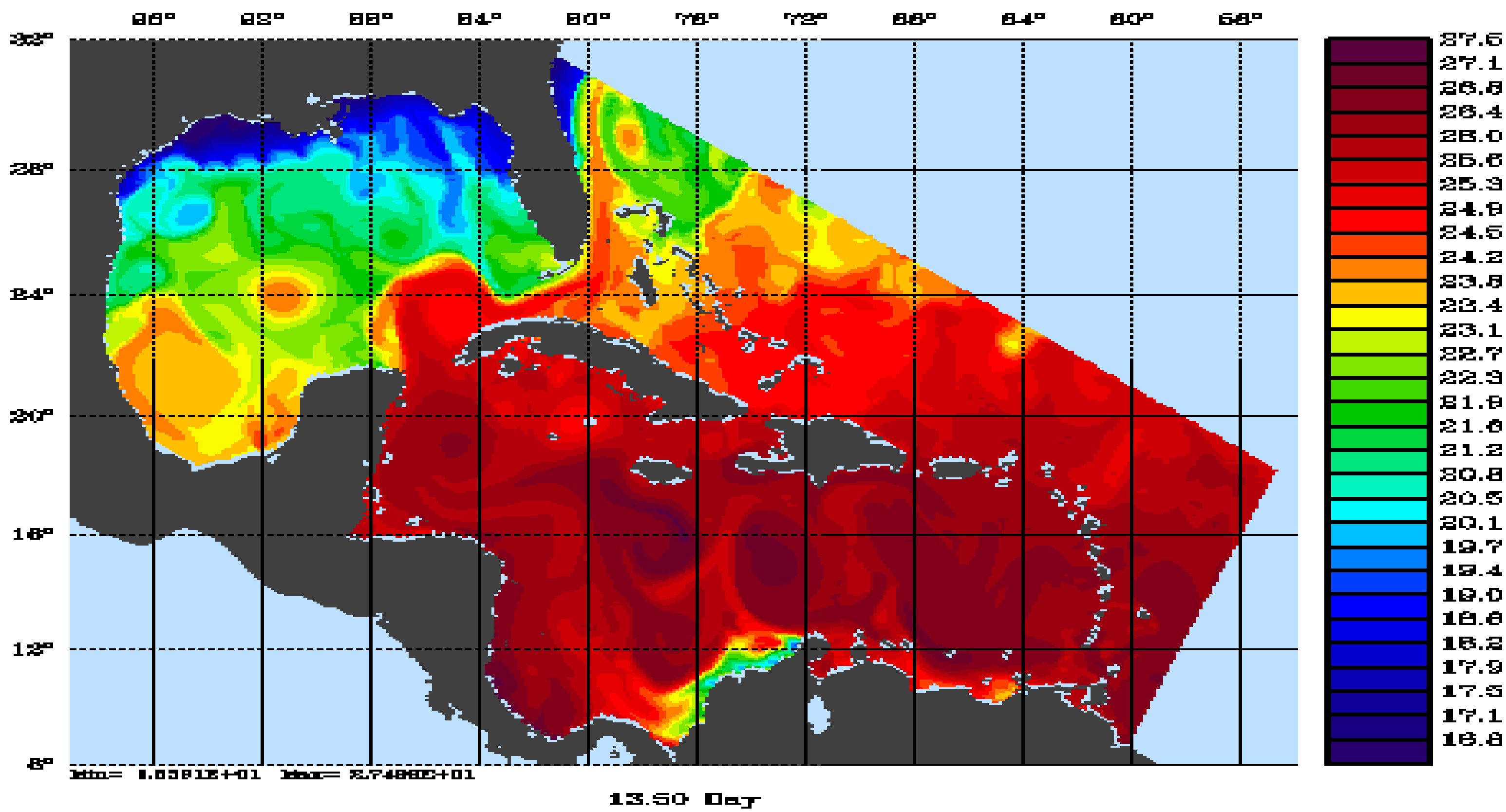
U(x,z)

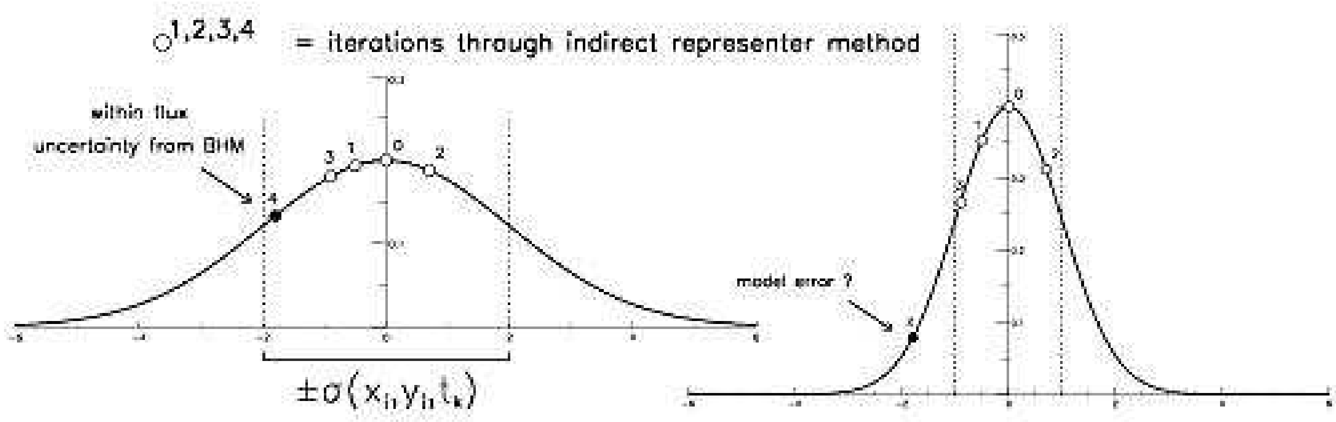
Standard Deviation Max = 5.9 *cm/s*

T(x,z)

Standard Deviation Max = 0.2°C

[SVW] to Identify Model Error in ROMS 4DVAR for the IAS





MFS-Wind-BHM *Markov Process Assumption → time dependence*

Data Stage Distributions (likelihoods)

$$\prod_{t=1}^{T}[S_t|W_t,\theta_S] \times \prod_{t=1}^{T}[A_t^w|W_t,\theta_{AW}][A_t^p|P_t,\theta_{AP}] \times \prod_{t=T+1}^{T+L}[F_t^w|W_t,\theta_{FW}][F_t^p|P_t,\theta_{FP}].$$

QSCAT ECMWF analyses ECMWF forecasts

Process Model Stage Distributions (priors) *"Stochastic Geostrophy"*

$$[b_0] \times \prod_{t=1}^{T+L}[W_t|P_t,\theta_W][P_t|b_t,\theta_P][b_t|b_{t-1},\theta_b]$$

Where $[P_t|b_t,\, \theta_P]$ is given by $P_t = \Phi b_t + \epsilon_p$ for spatial eigenvectors Φ and amplitude coefficients *b*.

In turn, $[b_t|b_{t-1},\, \theta_b]$ is an autoregressive model for *b* as in $b_t = G b_t + \epsilon_b$

Parameter Distributions

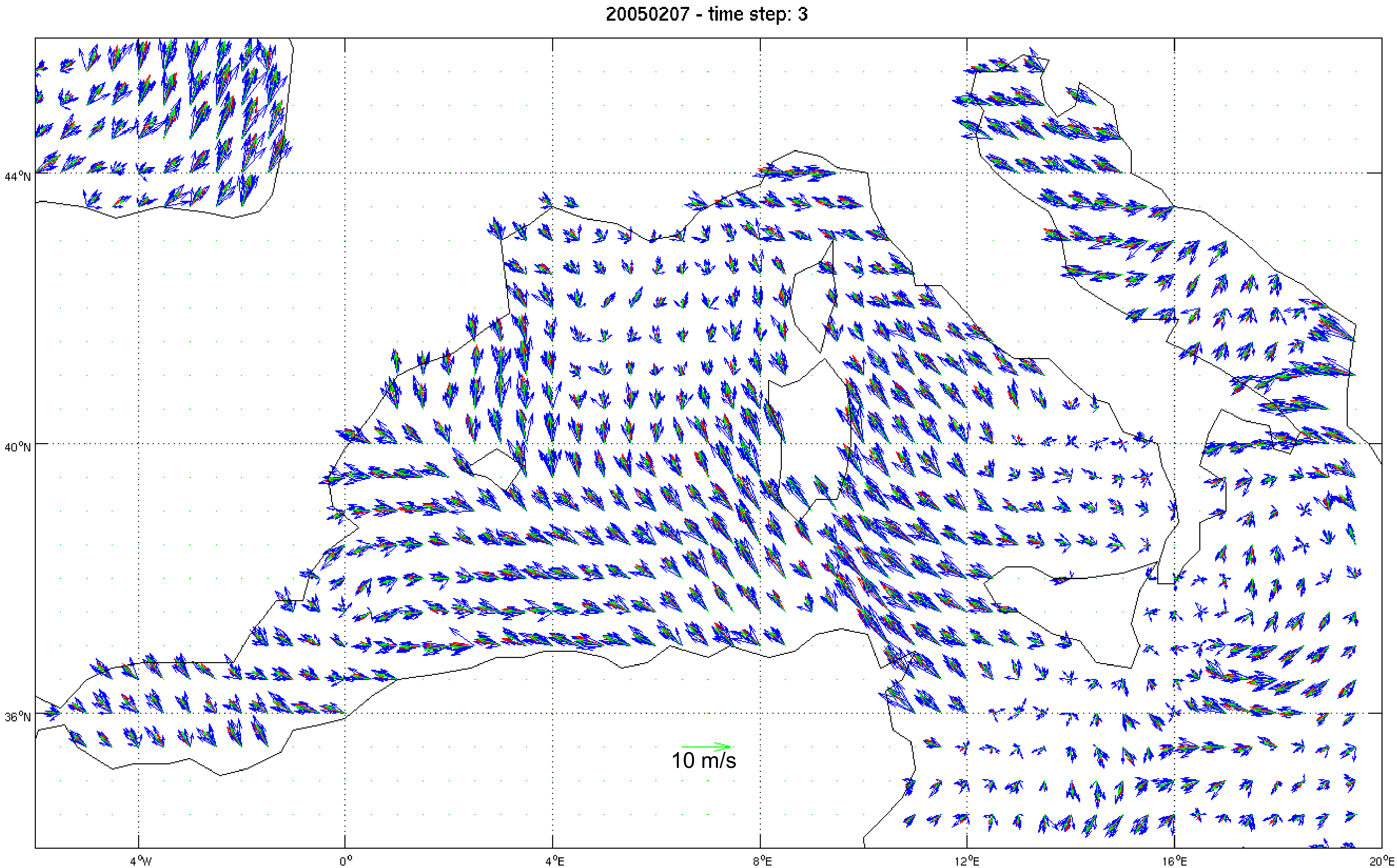
$$\theta_{S,AW,FW,AP,FP} = \{\mathrm{H}_{S,AW,FW,AP,FP},\, \sigma^2_{S,AW,FW,AP,FP}\};\ \theta_P = \{\Phi,\, \epsilon_p\};\ \theta_b = \{G,\, \epsilon_b\}; \ldots$$

Posterior Distribution

$$[W_t,\, P_t,\, b_t,\, \theta_{W,P,b,S,AW,FW,AP,FP}\,|\,S_t,\, A_t^W,\, A_t^P,\, F_t^W,\, F_t^P]$$

BHM Ensemble Winds

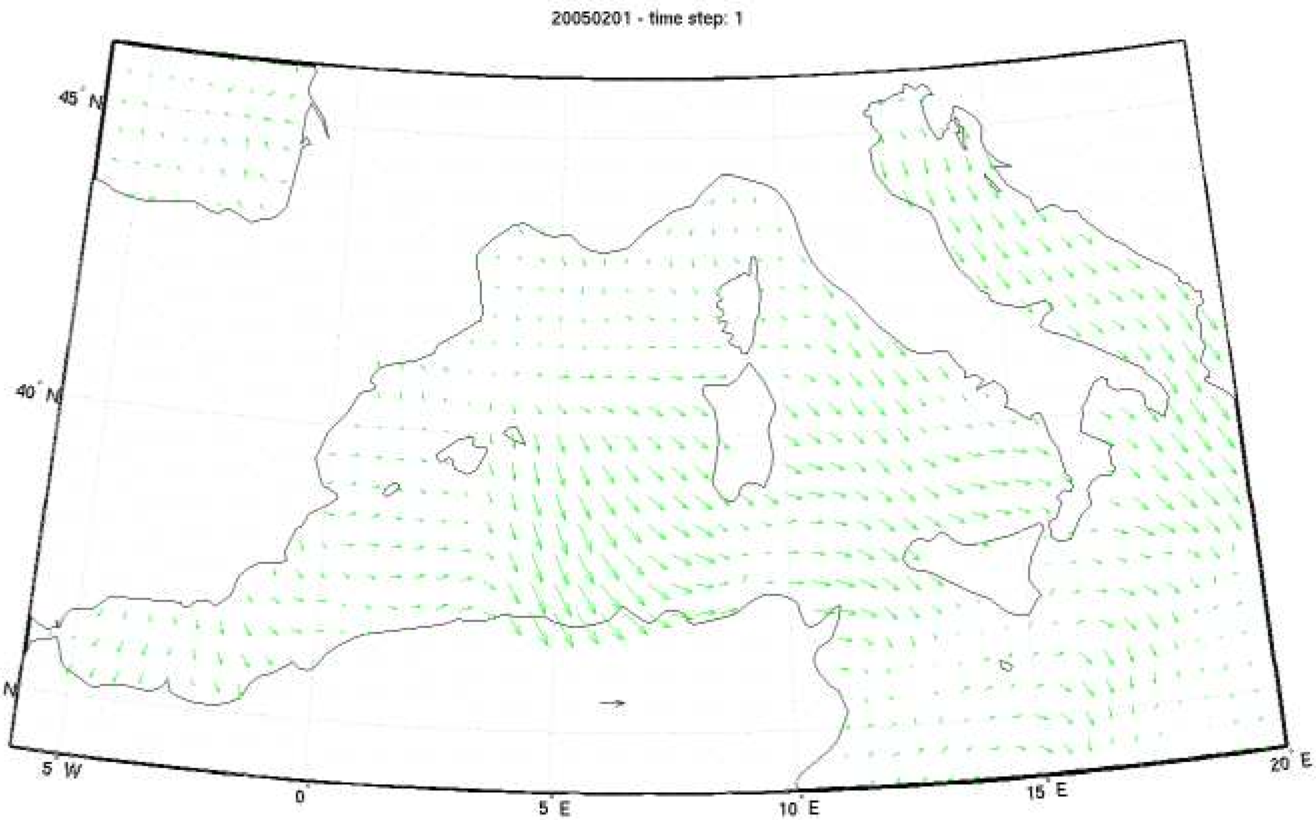
10 members selected from the Posterior Distribution (blue)



Ensemble mean wind (green); ECMWF Analysis wind (red)

BHM Ensemble Winds

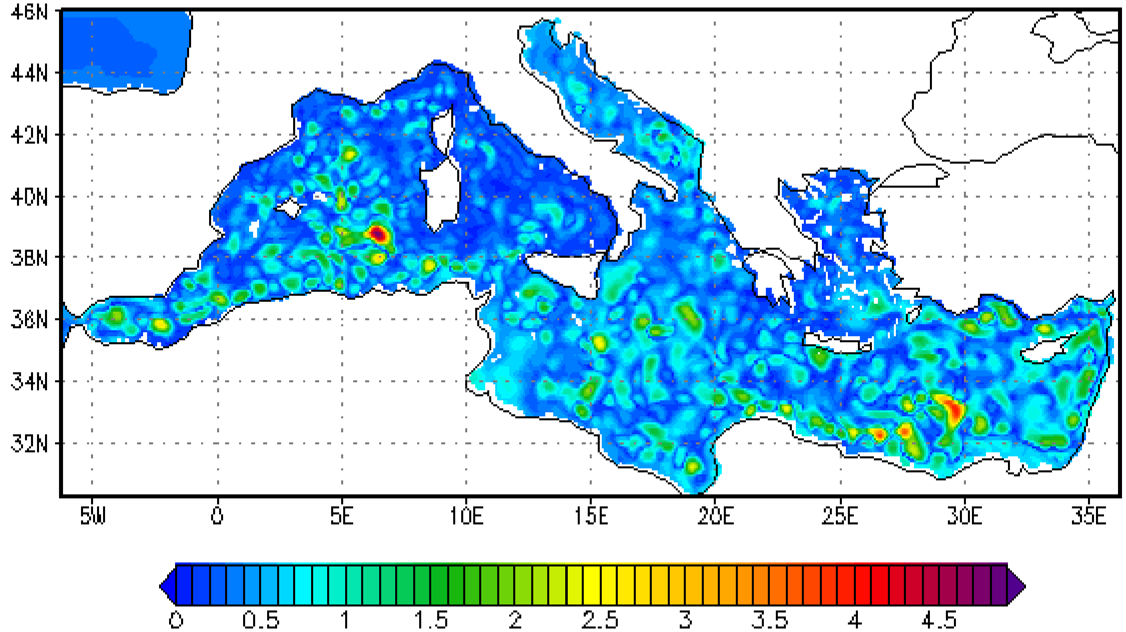
14d Analysis, 10d Forecast



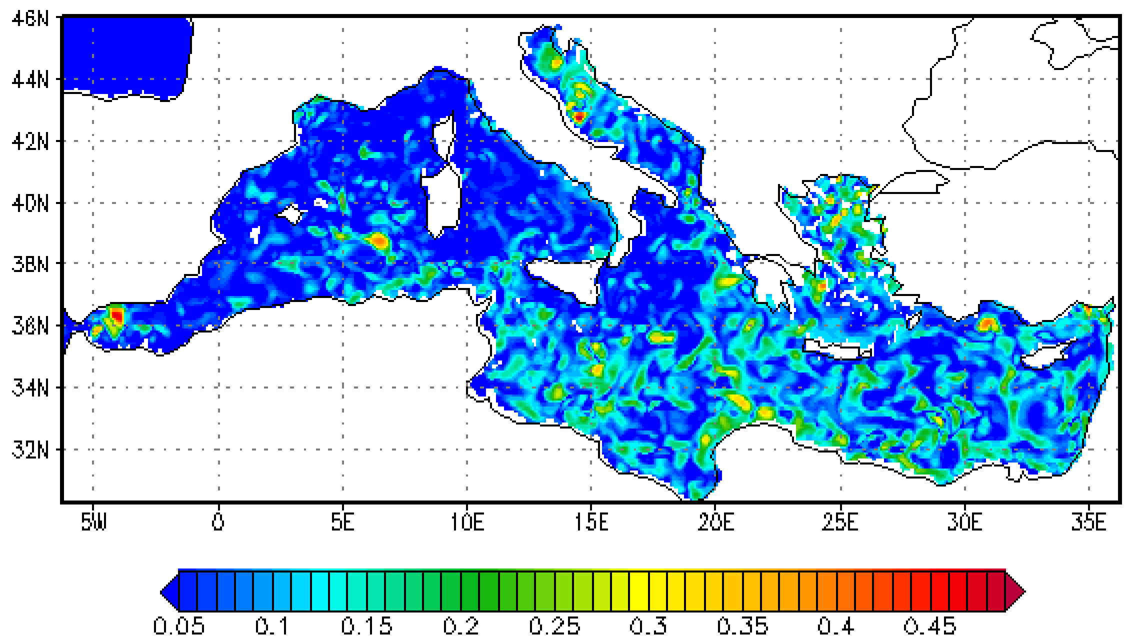
10 realizations from BHM posterior distribution (blue);
ensemble mean (green), ECMWF analysis (red)

Ensemble Initial Conditions

Day 14A



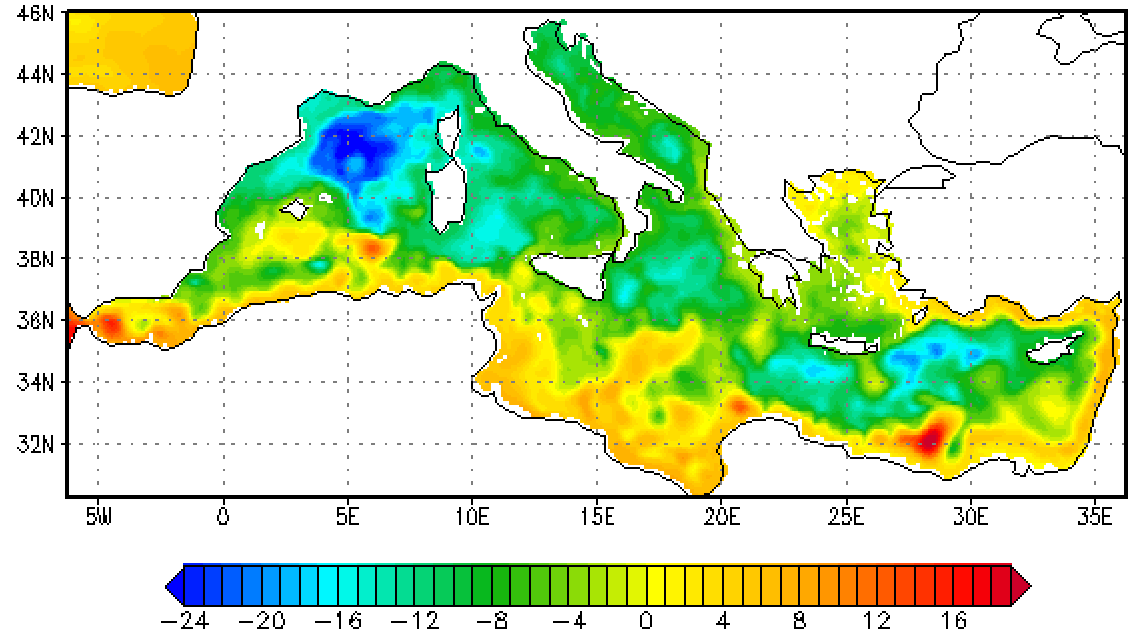
SSH Standard Deviation
(cm)



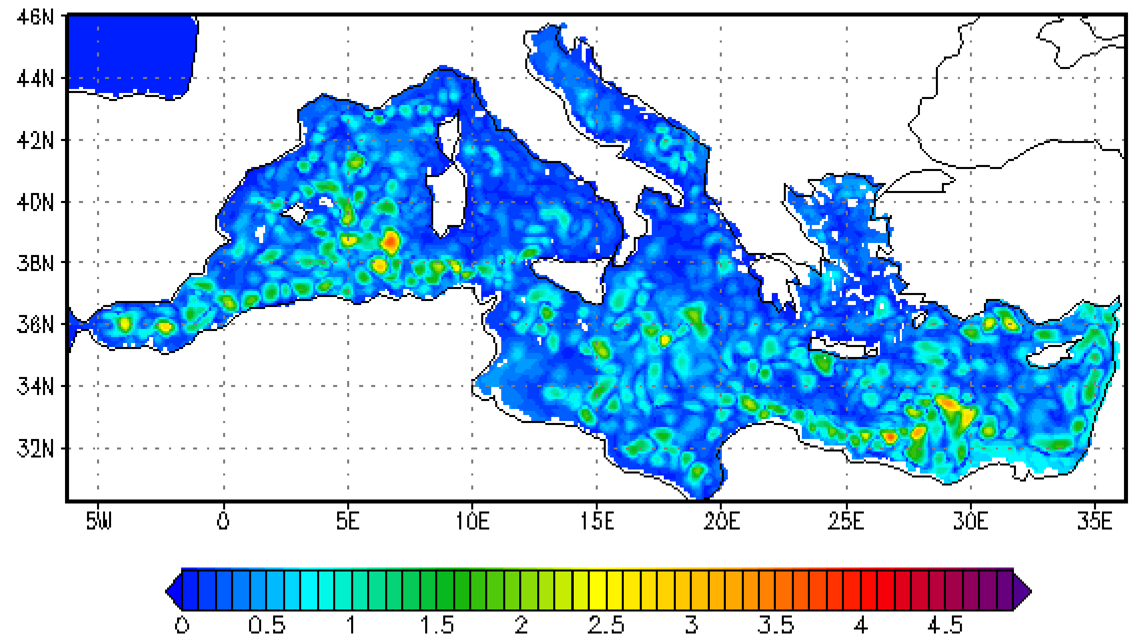
SST Standard Deviation
(°C)

MFS Ensemble Forecast Response

Day 3F



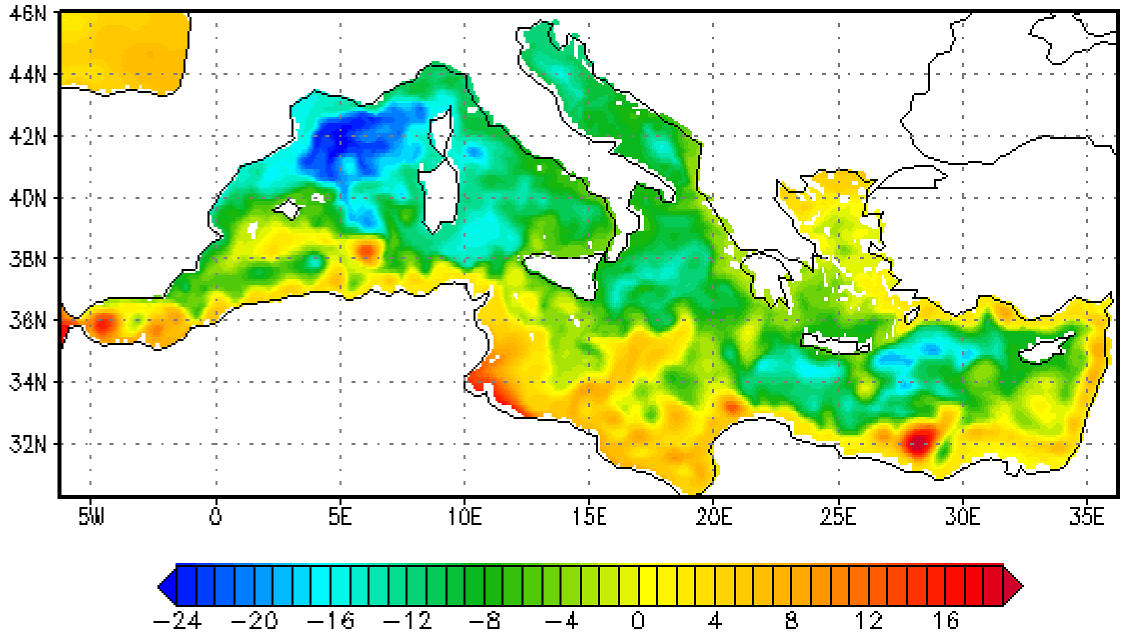
SSH Ensemble Mean
(cm)



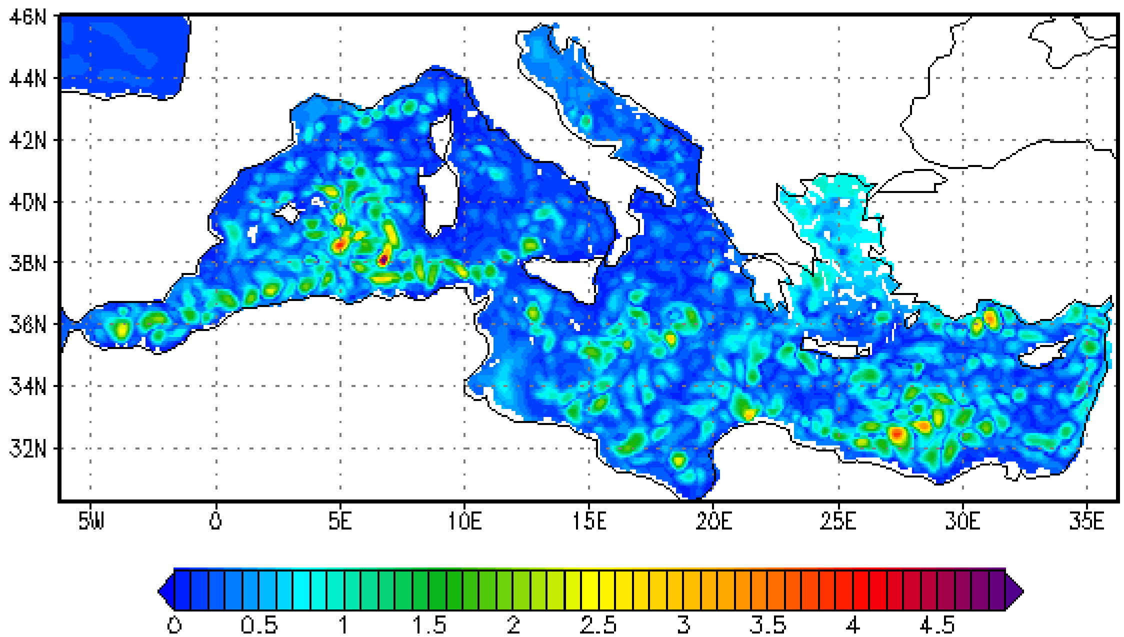
SSH Standard Deviation
(cm)

MFS Ensemble Forecast Response

Day 10F



SSH Ensemble Mean
(cm)



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