A Metric for Evaluation of Mapped QuikSCAT Wind Products

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Barcelona, Spain
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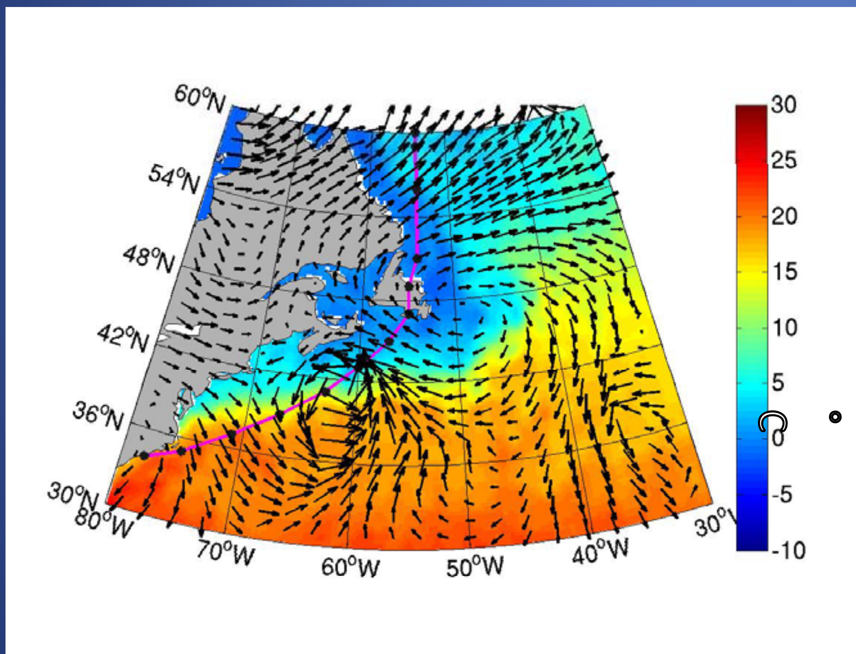
The influence of SST and surface heat fluxes on midlatitude storms

J. F. Booth, L. Thompson, J. Patoux, K. A. Kelly



Storm passing through the Gulf Stream region. Wind vectors, storm path (pink) and SST for a storm on Feb 24, 2001.

SST effects a storm's warm sector and moisture fluxes feed the storm's growth (Booth et al. 2010)

No correlation between a storm's intensification and temporal variability of SST

Assessment of Surface Heat Fluxes in Storms Modeled by WRF

S. C. Bates, J. F. Booth, L. Thompson, K. A. Kelly, S. Dickinson

QuikSCAT confirms that WRF:

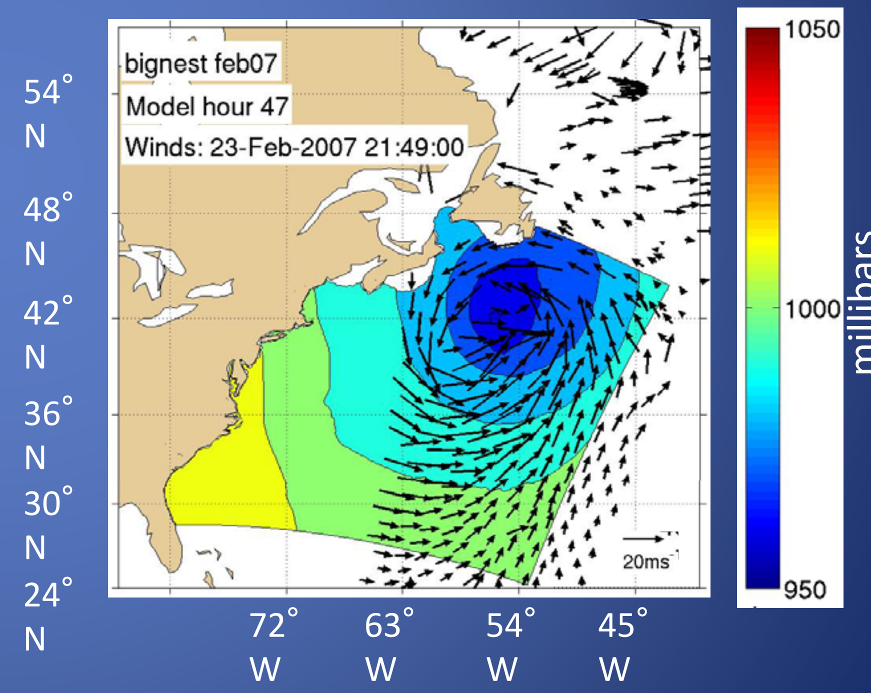
• reproduces storm shapes and positions well

• underestimates wind speeds over unstable regions

• has flux biases from WRF boundary layer scheme

• air-sea temperature difference (not winds) are responsible for flux bias

Model Hour 45
Date: 21:49 23Feb07

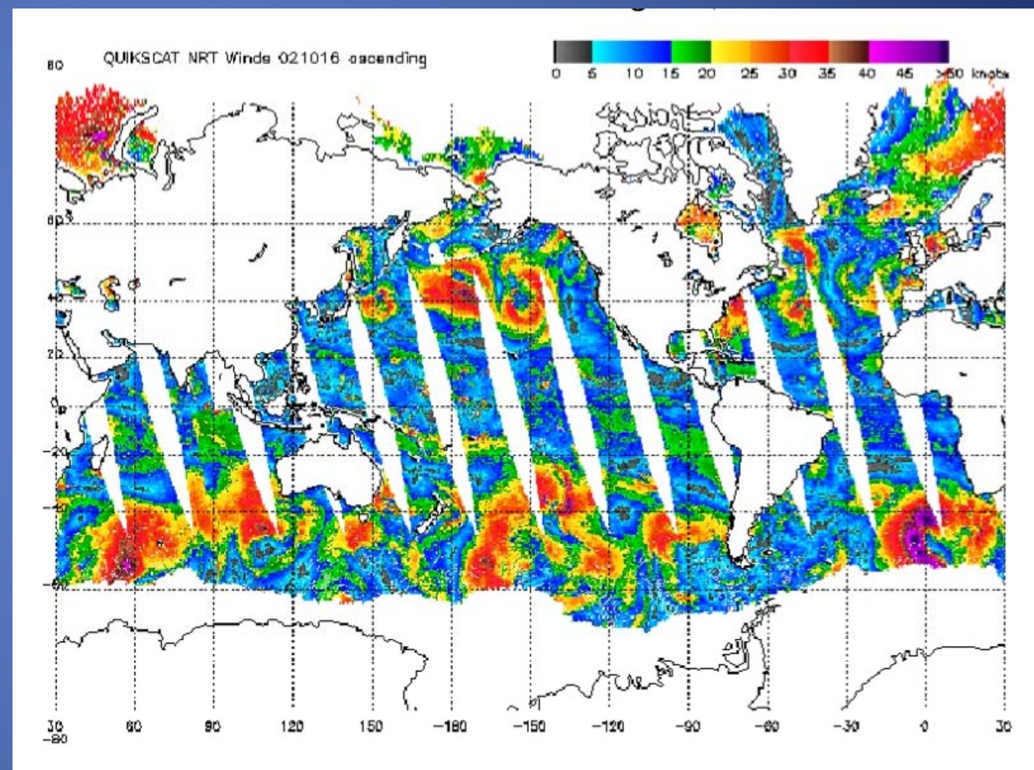


Need for a Metric

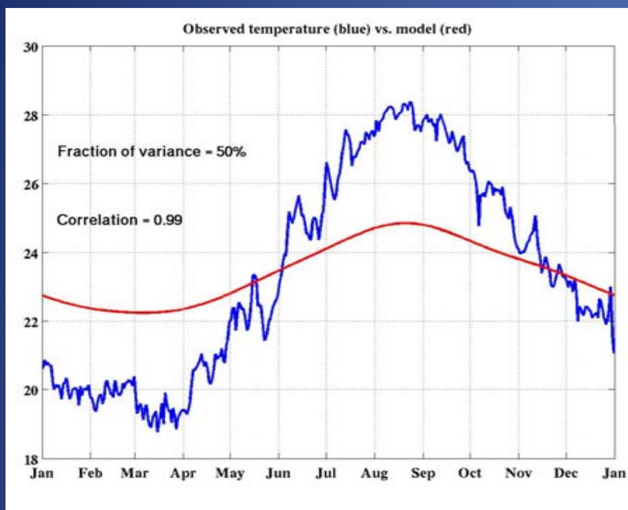
- Users need ways to determine which product appropriate for their application.
- Maps made with same data (12.5 km QuikSCAT) have varying time and spatial grids (resolution?).
- Different maps have different strengths, purposes. Users need guidance from Science Team.
- Post-QuikSCAT there is even more of a need to evaluate products (not homogeneous over time).

Mapping Scatterometer Data

- Assimilate data into NWP
- Blend data with other sources
- Average data in time (reduce aliasing)



Taylor Diagram: evaluate correlation and magnitude



Taylor diagram: plot correlation and magnitude in *polar coordinates*.
Squared error

$$<\varepsilon^2> = <d_m{}^2> + <d_o{}^2> - 2<d_m d_o> \qquad (2)$$

From *law of cosines*

$$<\varepsilon^2> = \sigma_m{}^2 + \sigma_o{}^2 - 2\sigma_m\sigma_o\cos\theta \qquad (3)$$

By definition,

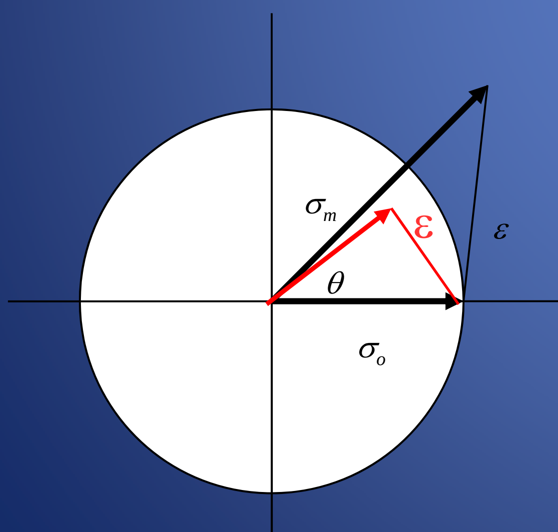
$$<d_m{}^2> = \sigma_m{}^2, <d_o{}^2> = \sigma_o{}^2$$

$$\rho = \cos\theta \quad or \quad \theta = \cos^{-1}\rho \quad (4)$$

$$<\varepsilon^2> = \sigma_m{}^2 + \sigma_o{}^2 - 2\sigma_m\sigma_o\cos^{-1}\rho \qquad (5)$$

Normalized Taylor diagram gives relative error ε / σ_o

$$\frac{<\varepsilon^2>}{\sigma_o{}^2} = \frac{\sigma_m{}^2}{\sigma_o{}^2} + 1 - 2\sigma_m\cos^{-1}\rho \qquad (6)$$



"Normalized error" ε

Vector Correlations:
use a version with compatible with scalar

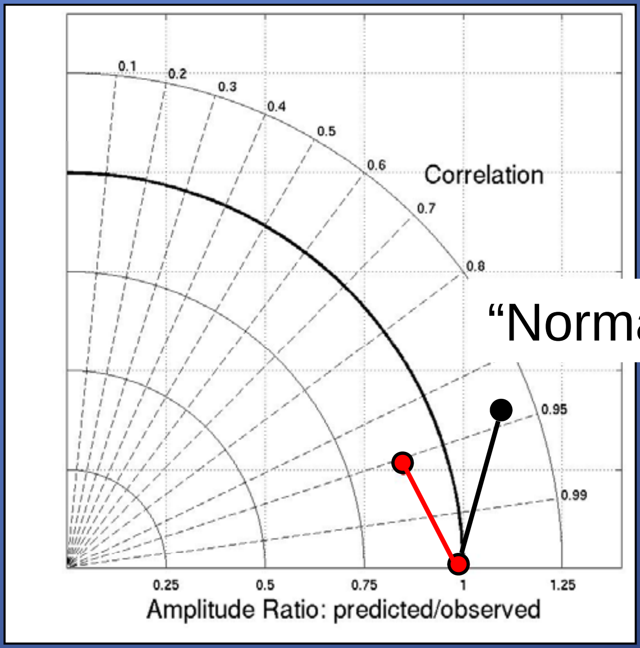
Time series of observations $\mathbf{v_o}(t) = u_o(t) + iv_o(t)$ and estimate $\mathbf{v_m}(t) = u_m(t) + iv_m(t) + \varepsilon$

Correlation of *anomalies*

$$\mathbf{r} = \frac{\mathbf{v_m}^{*}\mathbf{v_o}}{\sigma(v_m)\sigma(v_o)};$$

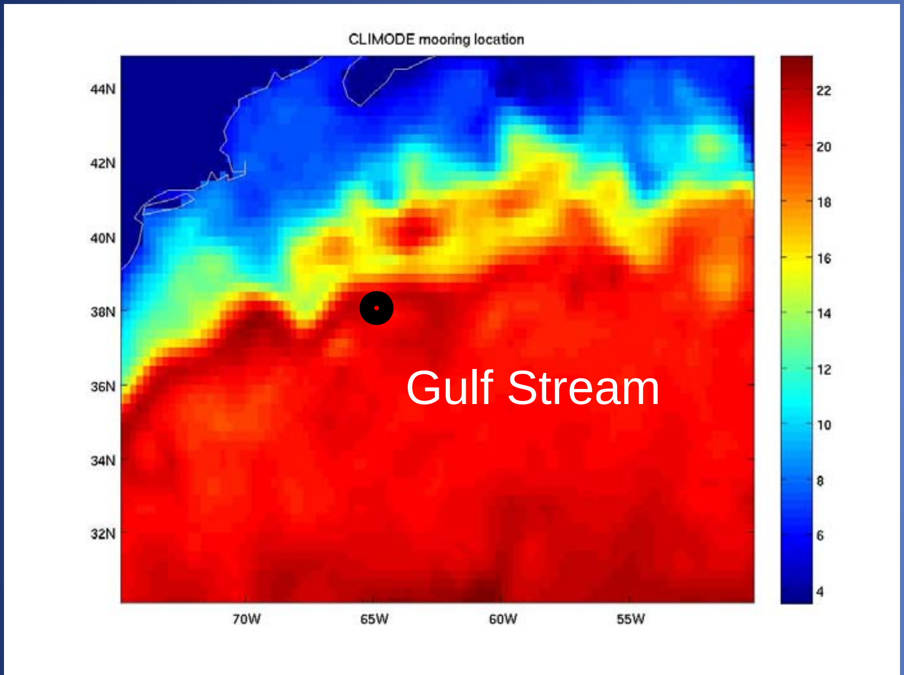
This version of complex correlation gives:

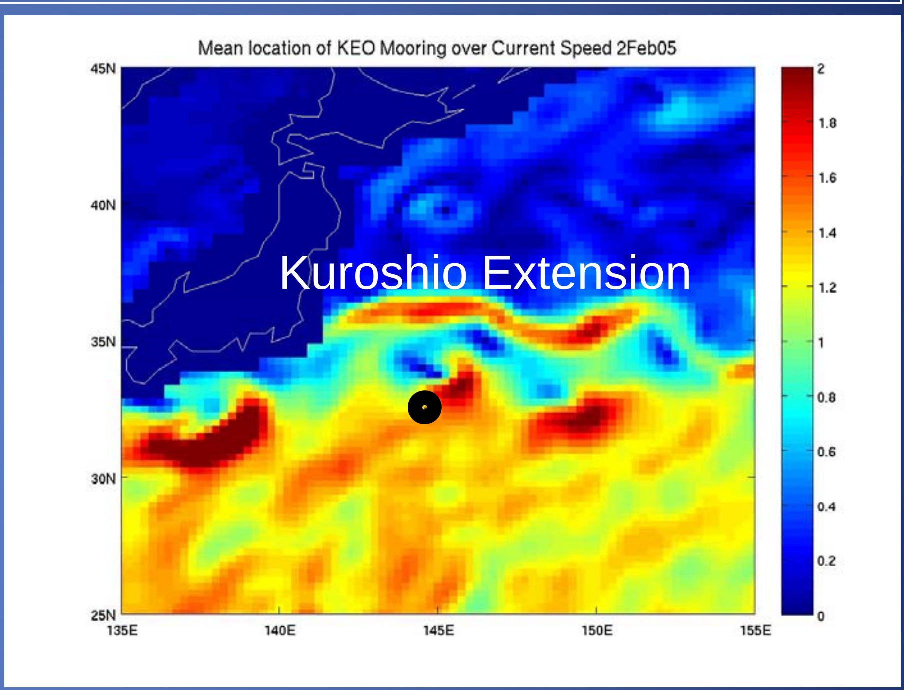
- magnitude of r: 0-1
- angle between vectors



In-situ Data – Open Ocean

Two research moorings located in Western Boundary Currents.
These are regions of high currents and steep SST gradients.





CLIMODE Mooring: Nov '05 – Jan '07
(14 mos) sonic anemometer

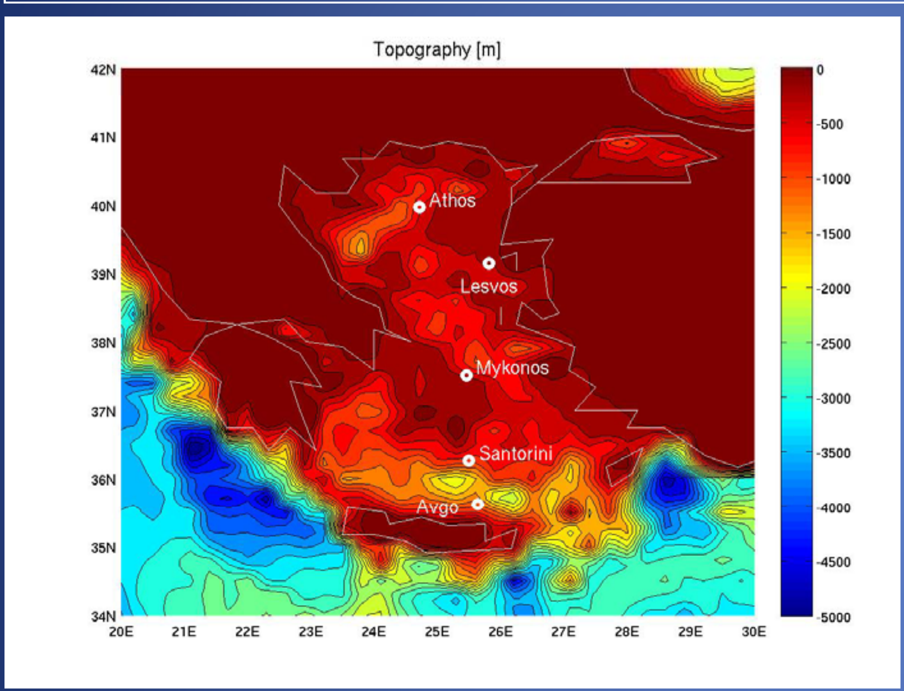
CLIvar MOde Water Dynamics Experiment
(NSF)

KEO Mooring: Jun '04 – Jul '08
(4 years with gaps) sonic anemometer

Kuroshio Extension Observatory
Pacific Marine Environmental Lab
(NOAA)

In-situ Data – Near Land

Five buoys located in the Aegean Sea. Land contaminates the scatterometer signal. Variable winds persist on scales on the order of the QuikSCAT footprint.



Aegean Sea Buoys: Jul '99 – May '04
(5 years with gaps)

Poseidon System, Hellenic Centre for Marine Research (EFTA)

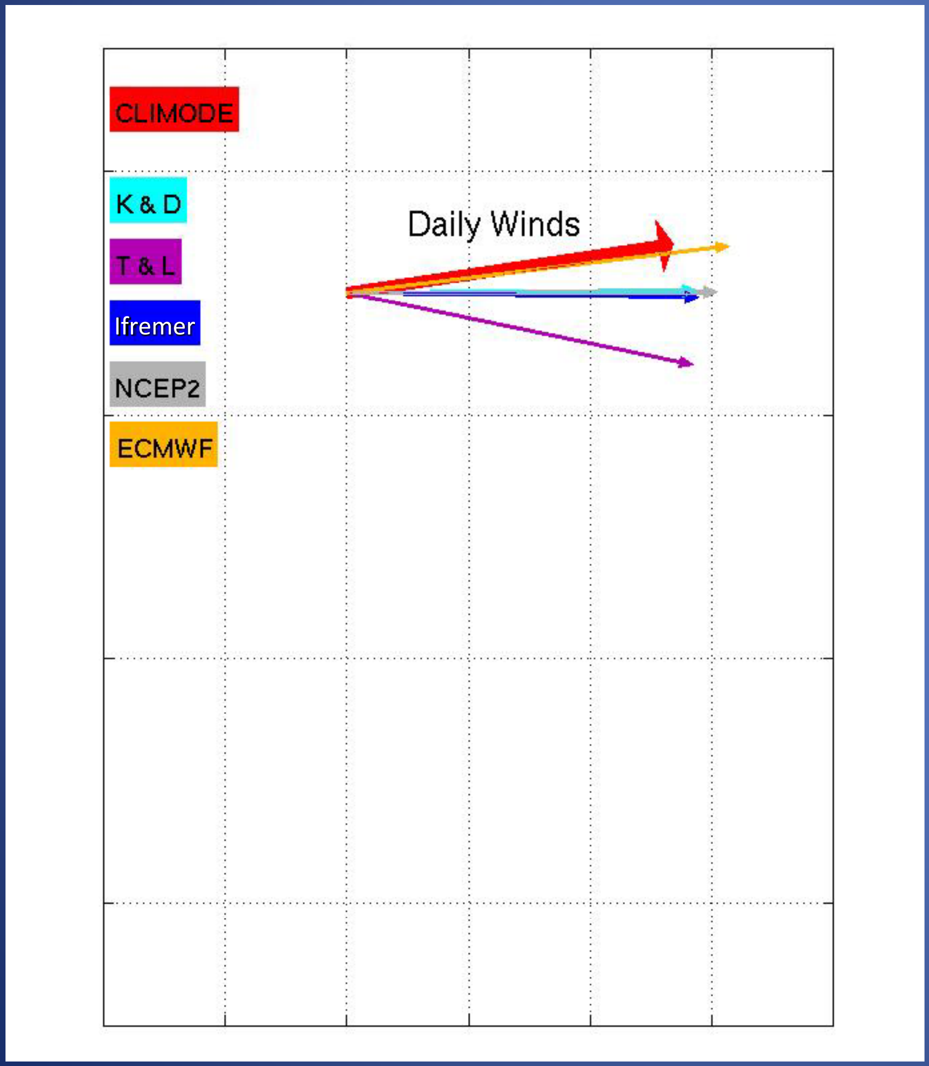
All in-situ winds converted to 10m in neutrally stratified atmosphere with COARE v3.0 algorithm.

• Metadata amended with ECMWF variables where needed.

• Used in-situ currents when available.

Winds below 3 m/s not included in analysis.

Mean Vectors at CLIMODE Mooring
Daily Wind Maps



Kelly & Dickinson
- daily, ½ degree

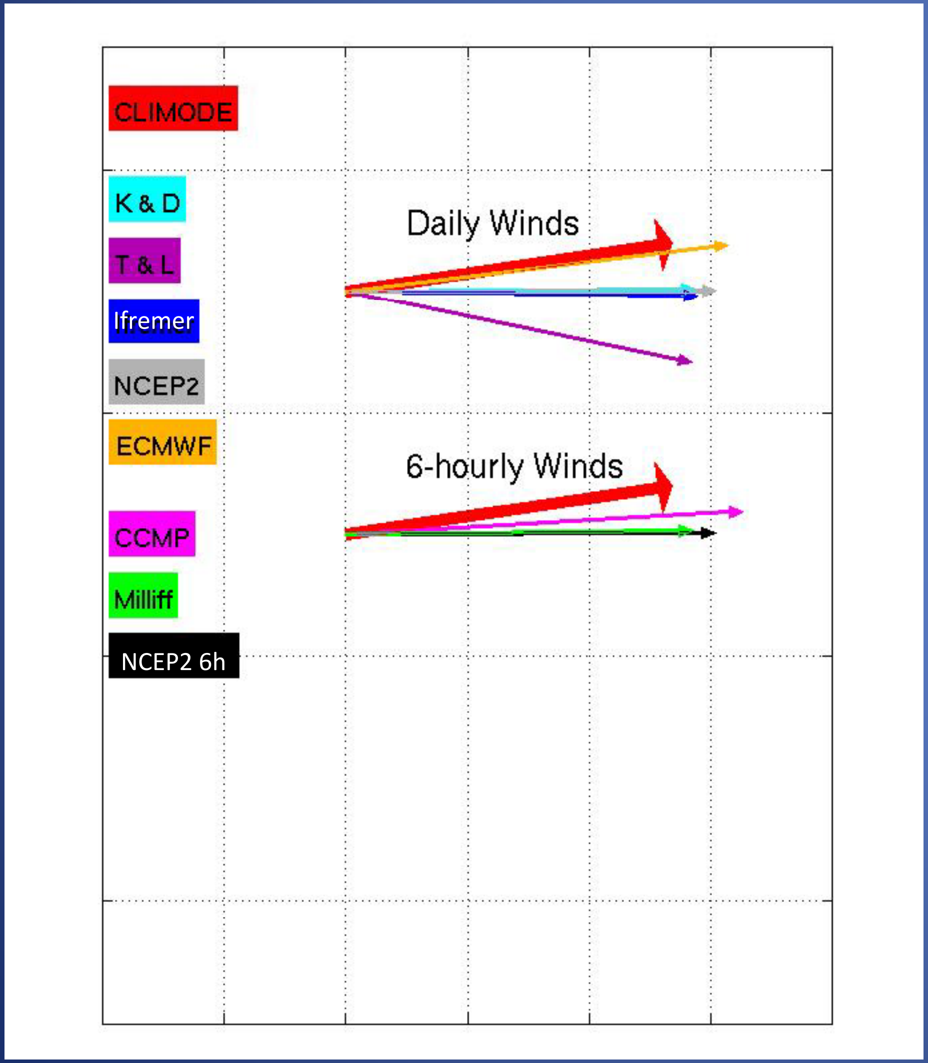
Tang & Liu
- 12-hourly, ½ degree

Ifremer
- daily, ½ degree

NCEP2
- daily, gaussian ~1.9 deg

ECMWF
- daily, gaussian, ~1.1 deg

Mean Vectors at CLIMODE Mooring 6-hourly Wind Maps

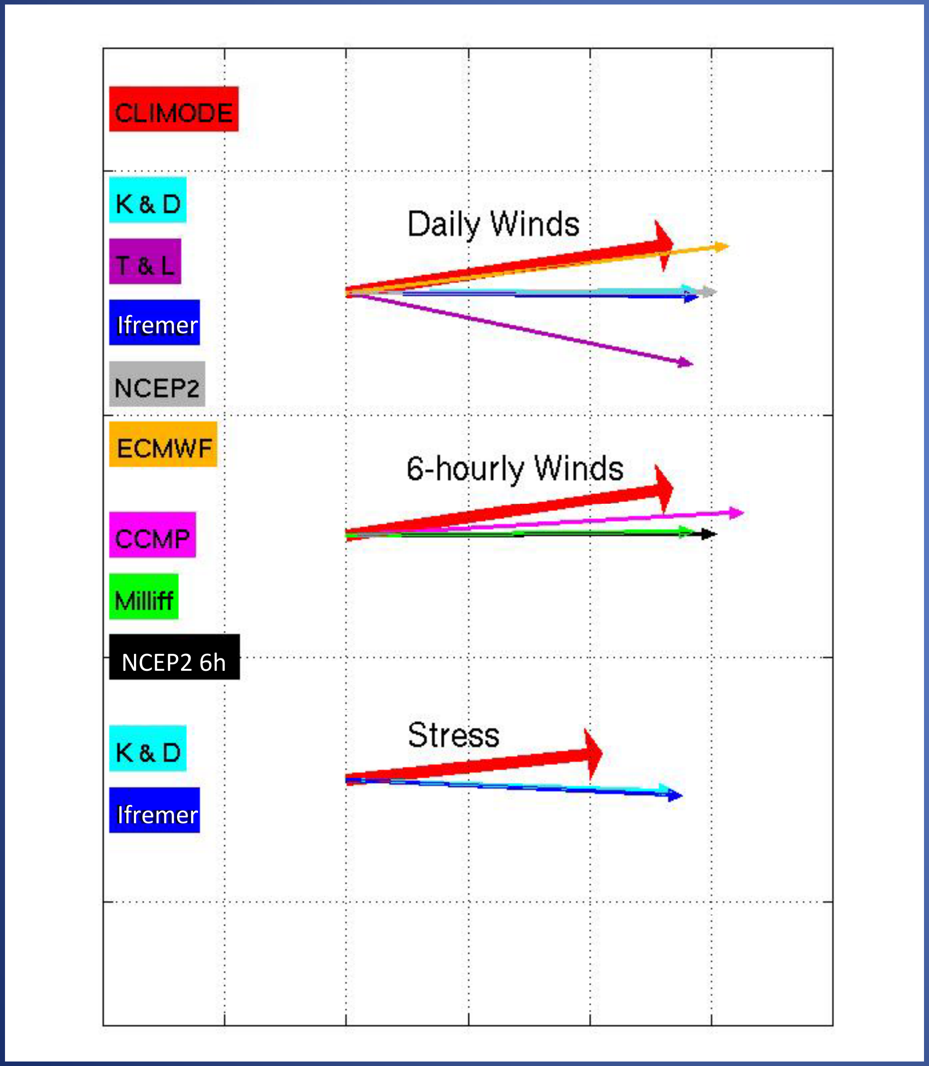


Cross-calibrated, multi-Platform
- 6-hourly, ¼ degree

Milliff (blended)
- 6-hourly, ½ degree

NCEP2-6h
- 6-hourly, gaussian, ~1.9 deg

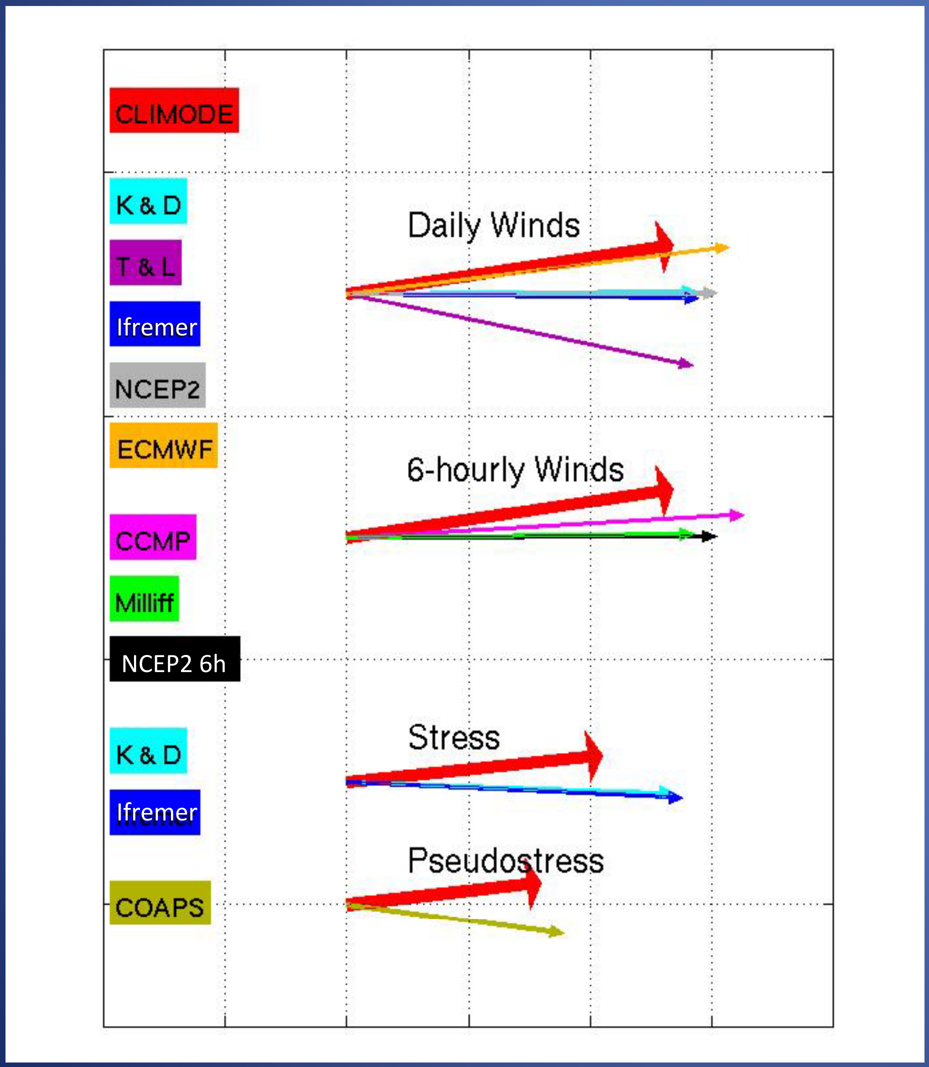
Mean Vectors at CLIMODE Mooring Stress Maps



Kelly & Dickinson
- daily, ½ deg

Ifremer
- daily, ½ deg

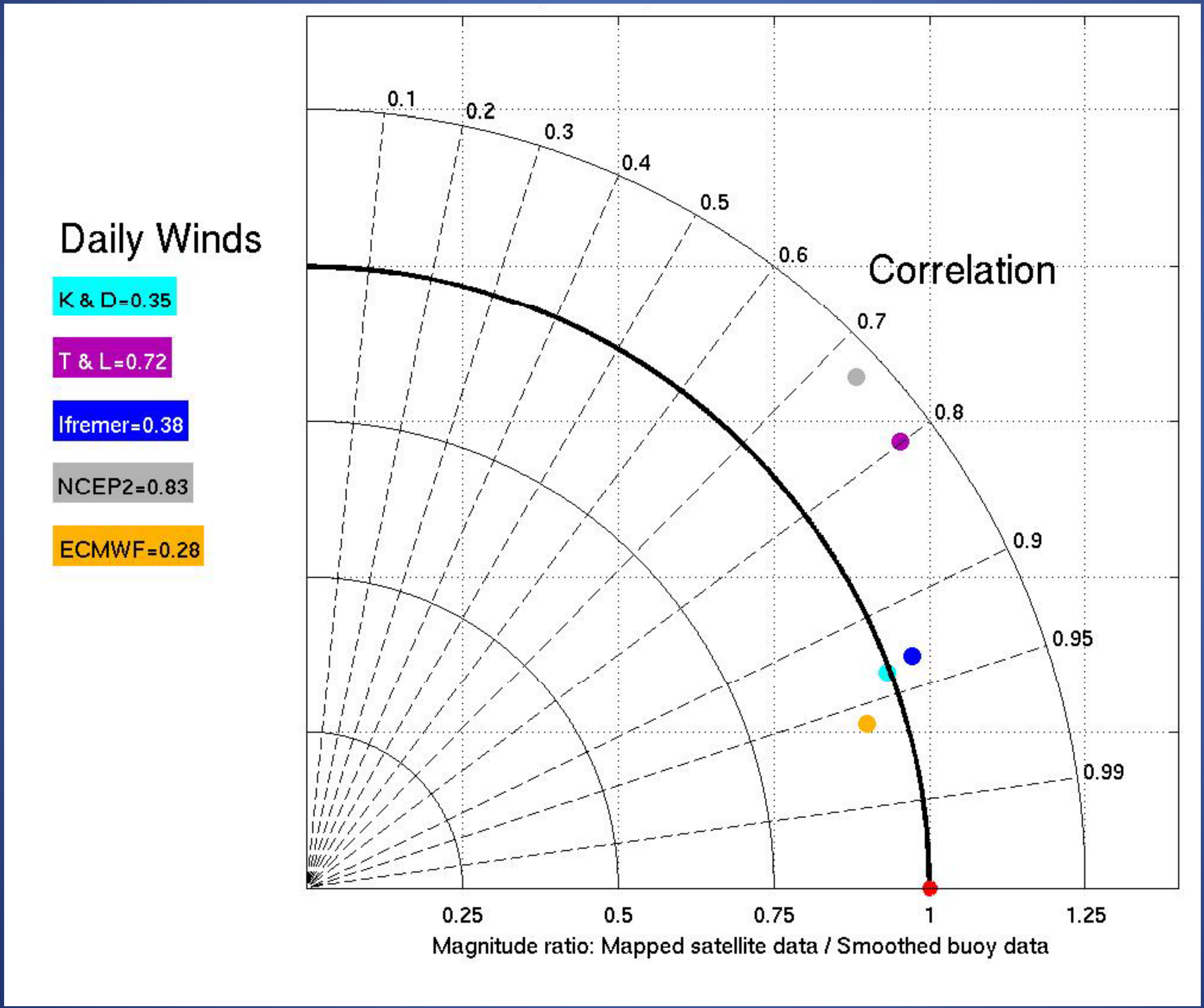
Mean Vectors at CLIMODE Mooring
Pseudostress Maps



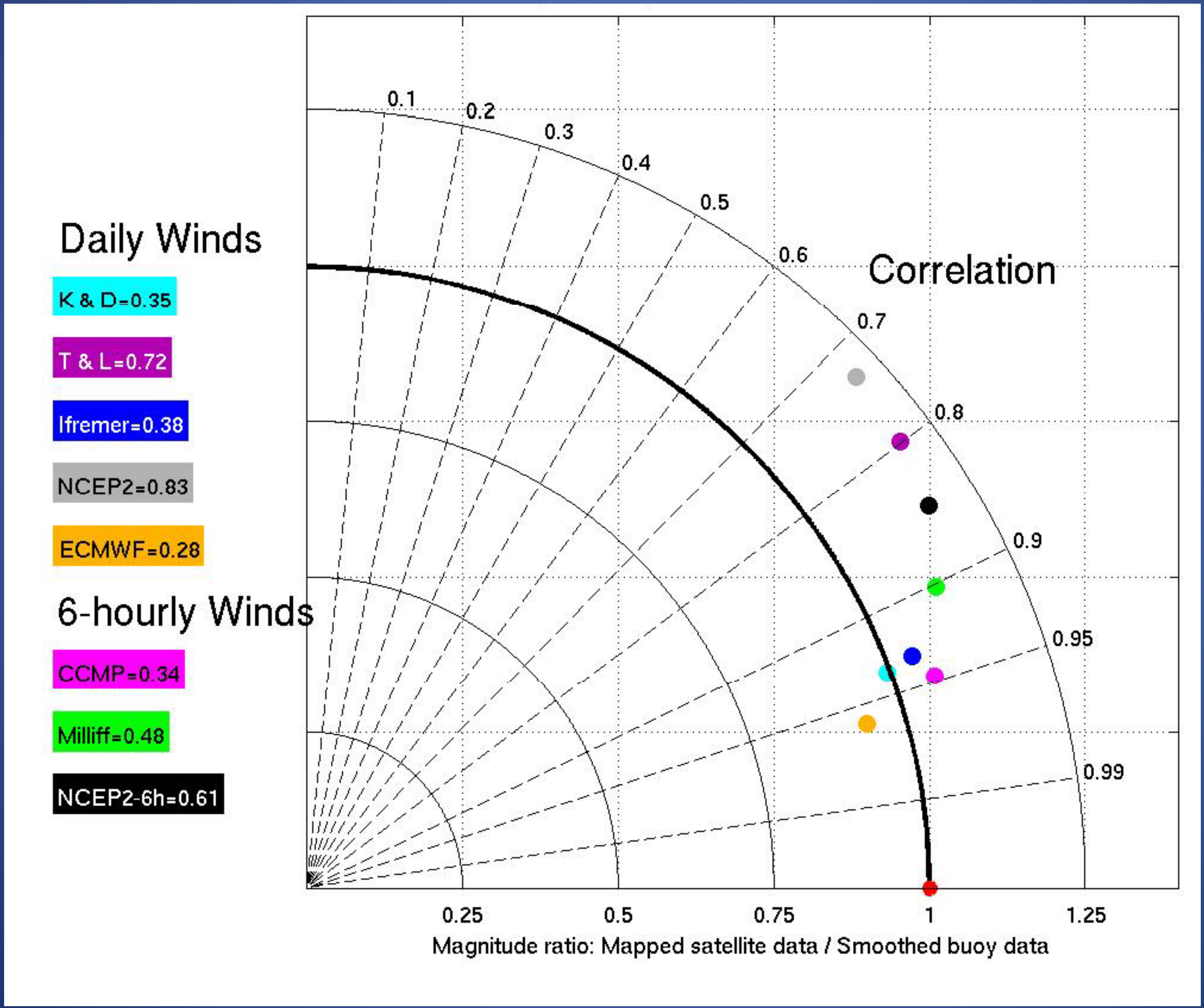
Center for Ocean-Atmosphere Predictions Studies

- 6-hourly, 1 deg

Taylor Diagram – CLIMODE Mooring Daily Winds



Taylor Diagram – CLIMODE Mooring 6-hourly Winds

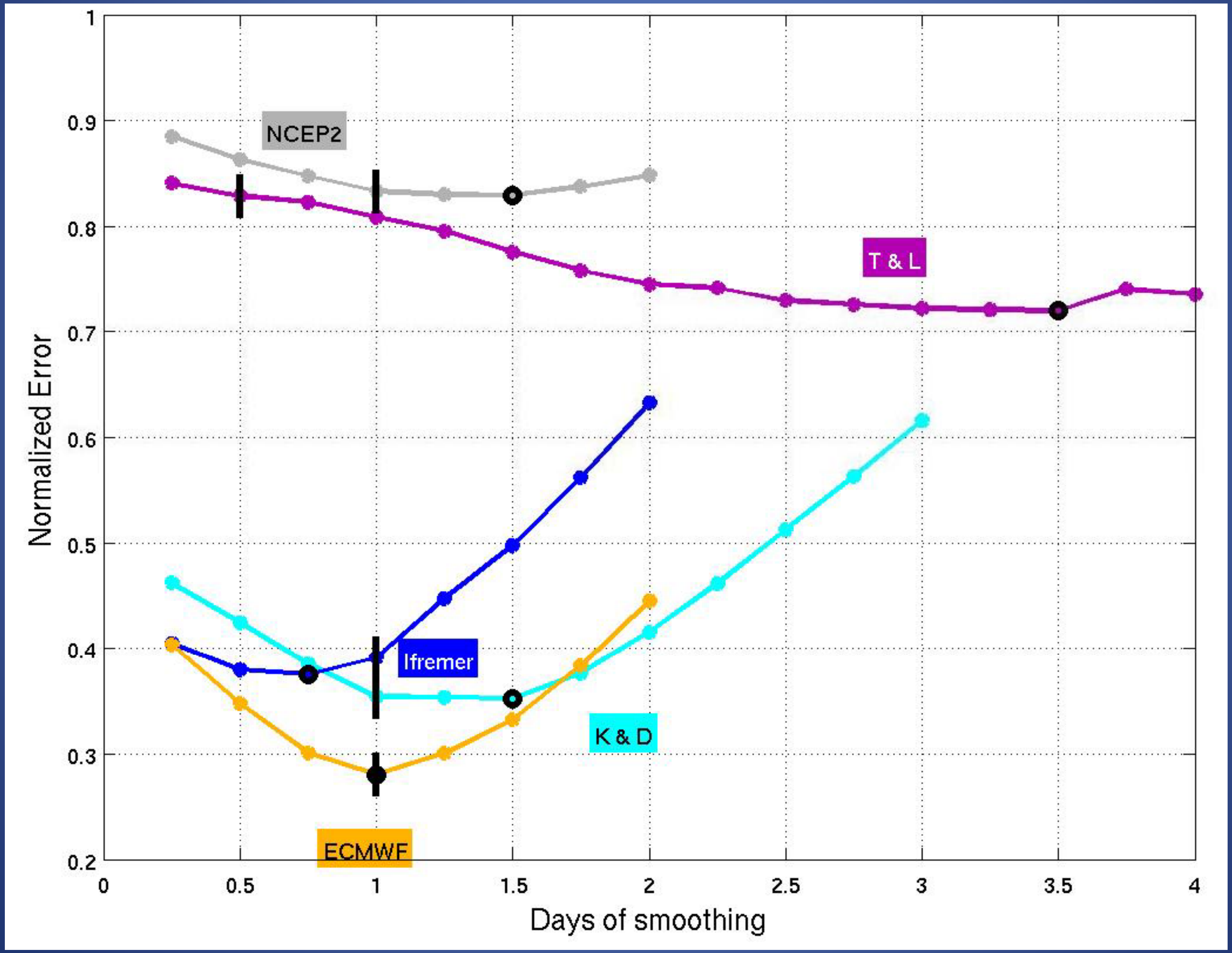


Estimate Temporal Resolution

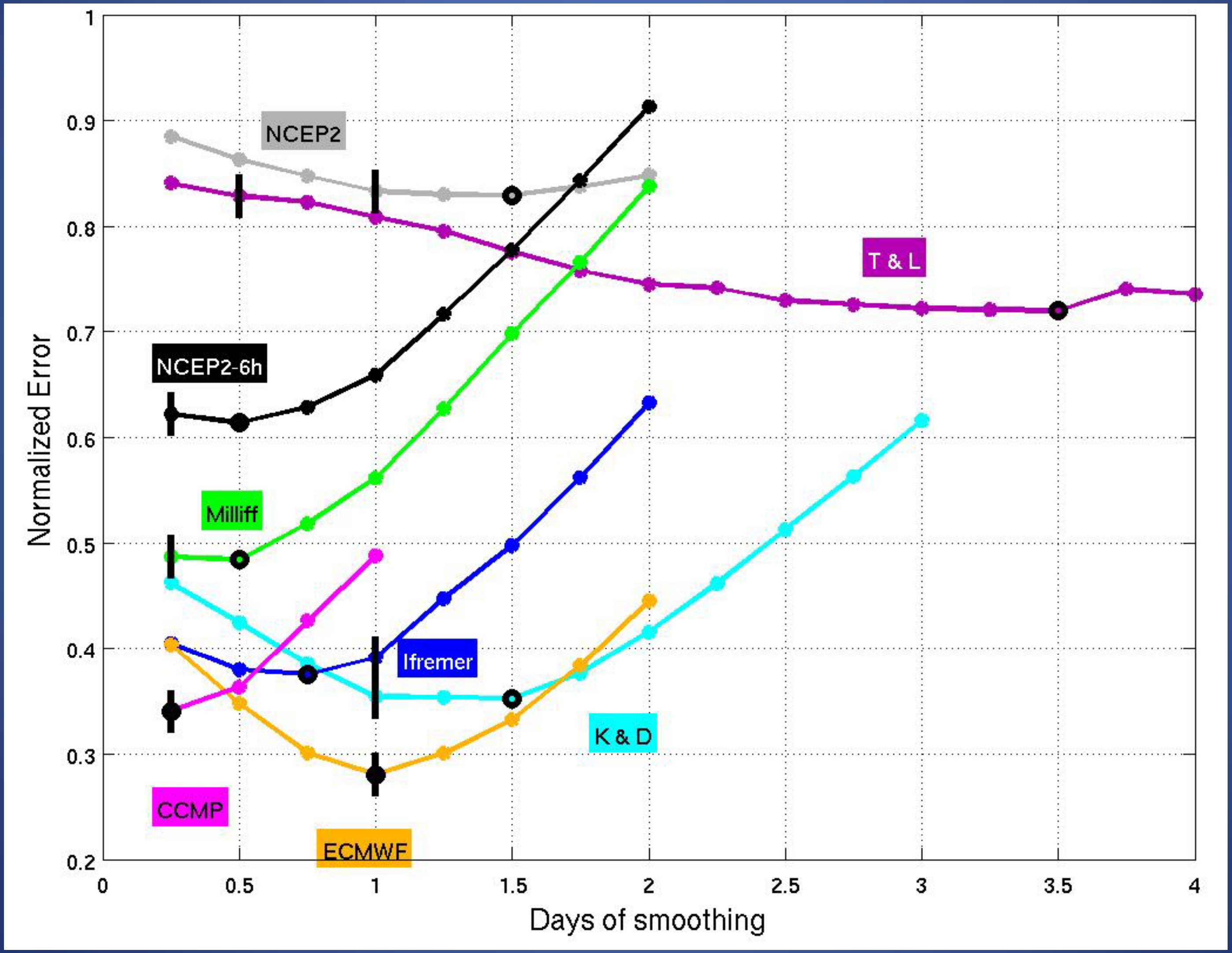
Procedure:

1) Smooth buoy winds at various intervals (3 hr, 6 hr, 12 hr, etc)
2) Compute "normalized error" between gridded product and smoothed buoy winds
3) Nominal resolution is interval with minimum normalized error

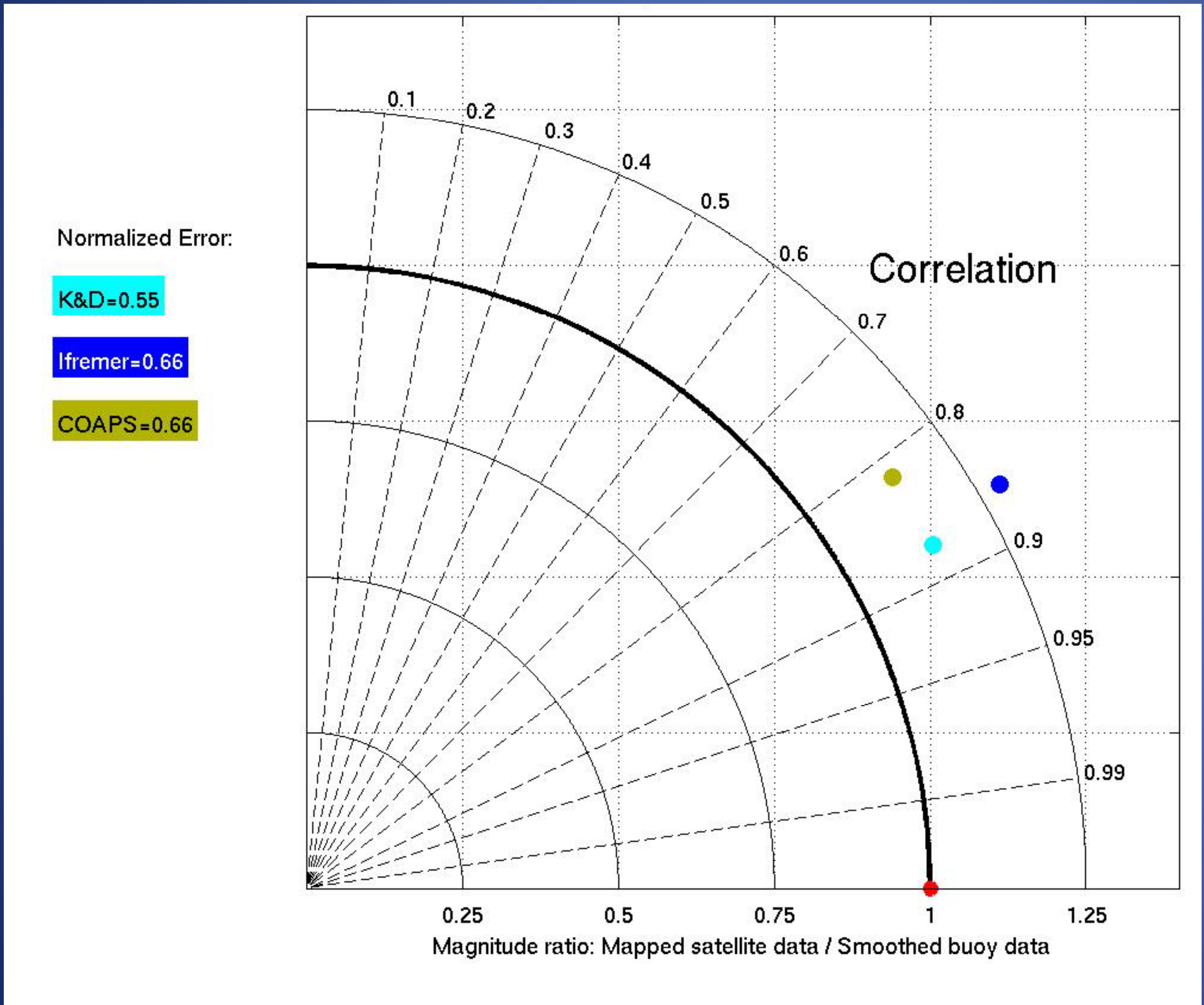
Normalized Error vs Averaging Bin
CLIMODE Mooring – Daily Winds



Normalized Error vs Averaging Bin
CLIMODE Mooring – 6-hourly Winds



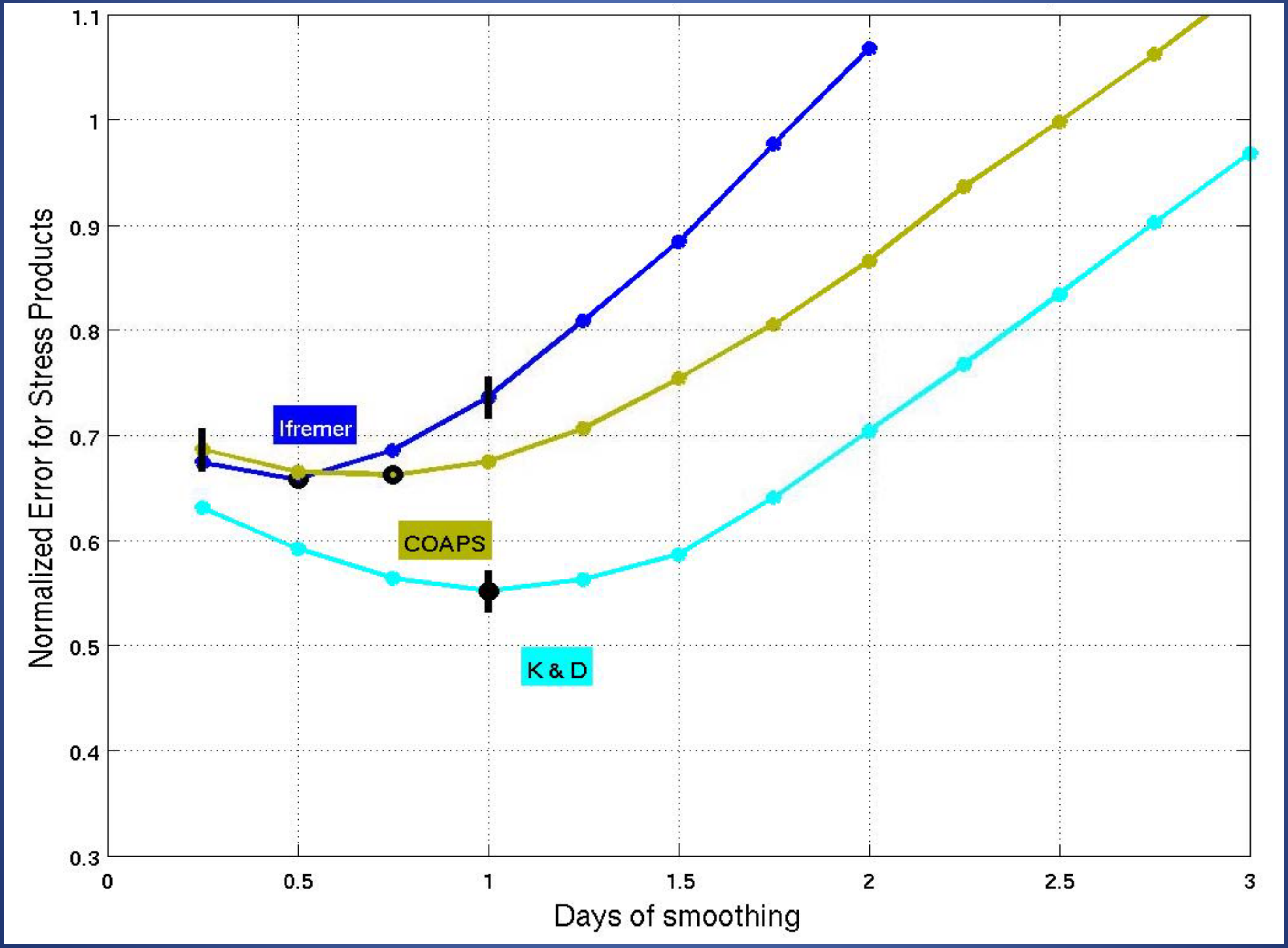
Stress and Pseudostress Maps CLIMODE Mooring



NOTE:

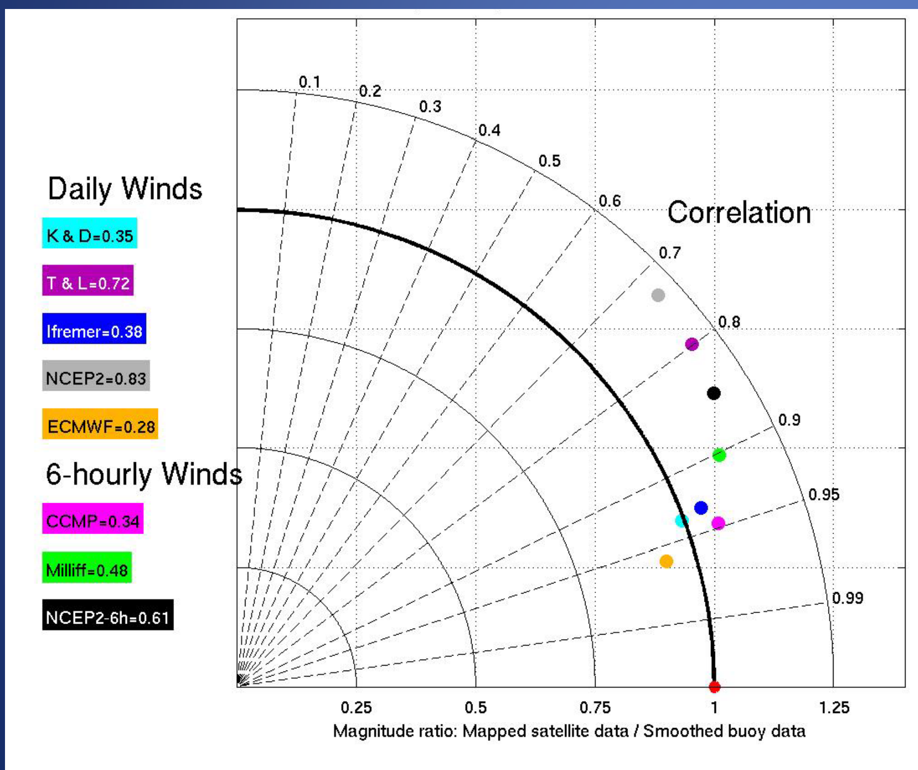
C_d for stress calculations at buoys and for Kelly & Dickinson maps, Large et al. 1994

Stress and Pseudostress Maps
CLIMODE Mooring

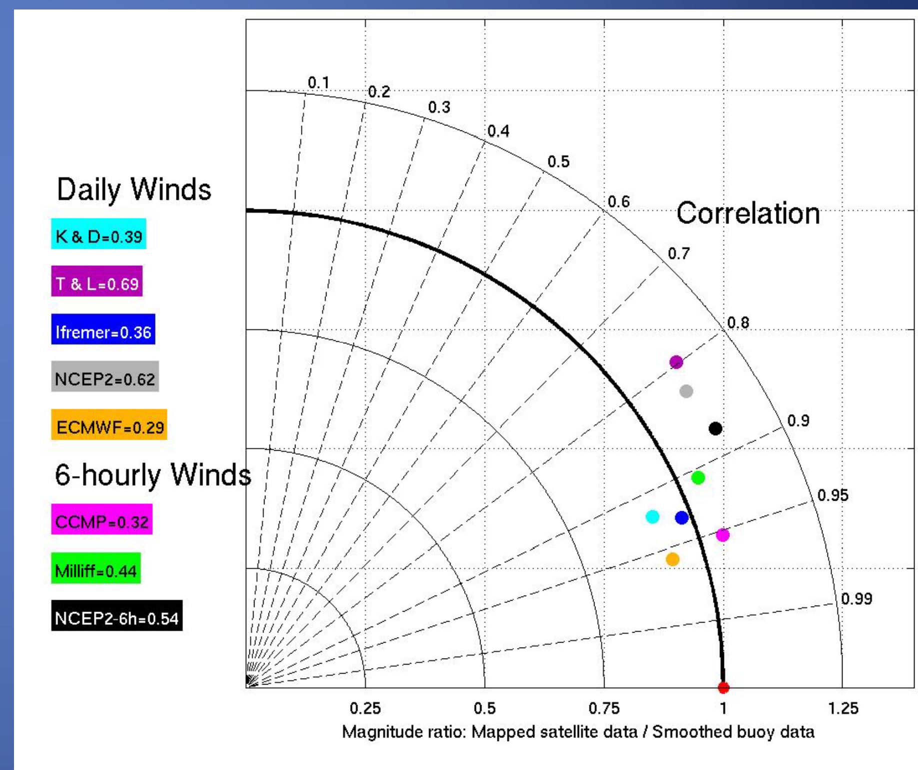


Taylor Diagram – KEO Mooring
Daily and 6-hourly Winds

CLIMODE

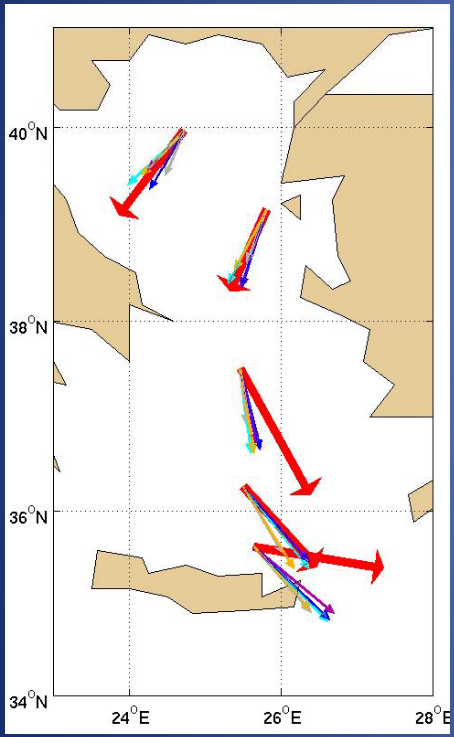


KEO

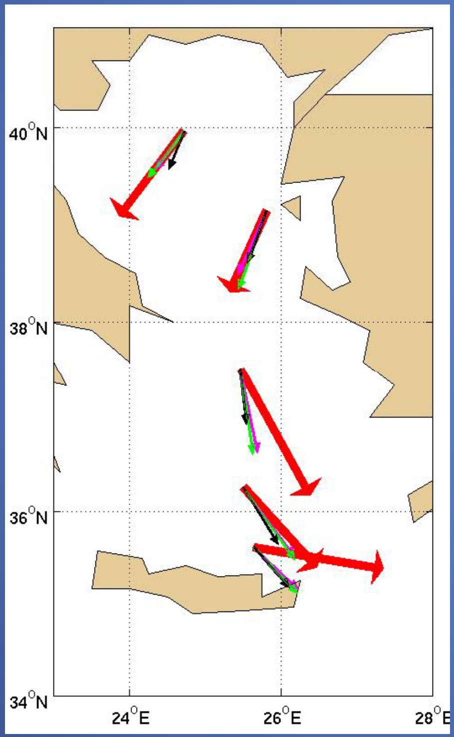


Mean Vectors – Aegean Buoys

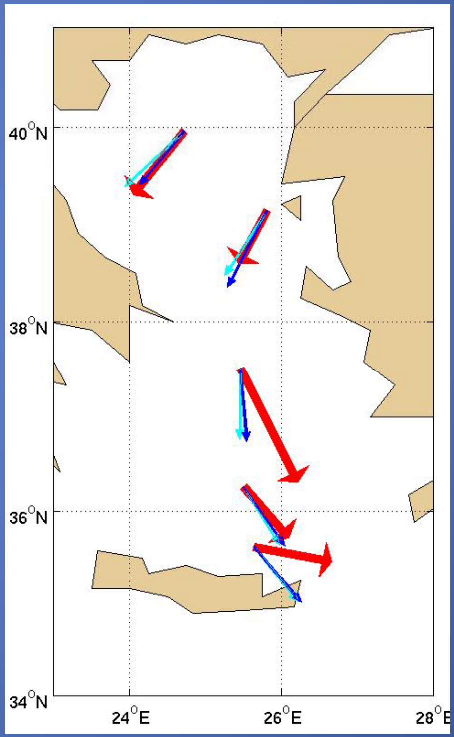
Daily Winds



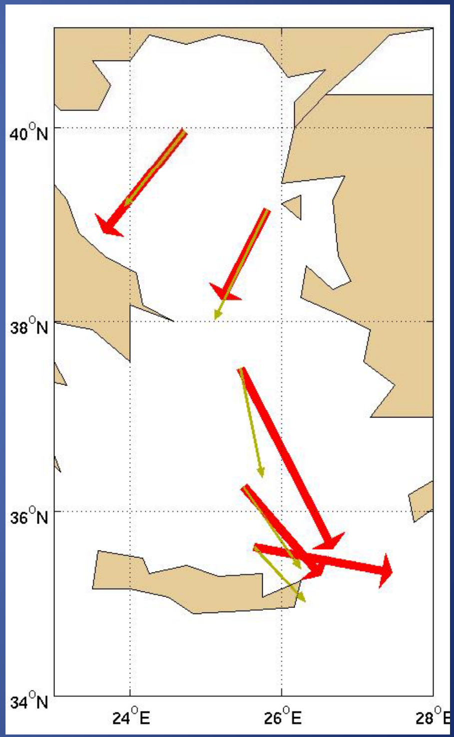
6-hourly Winds



Stress

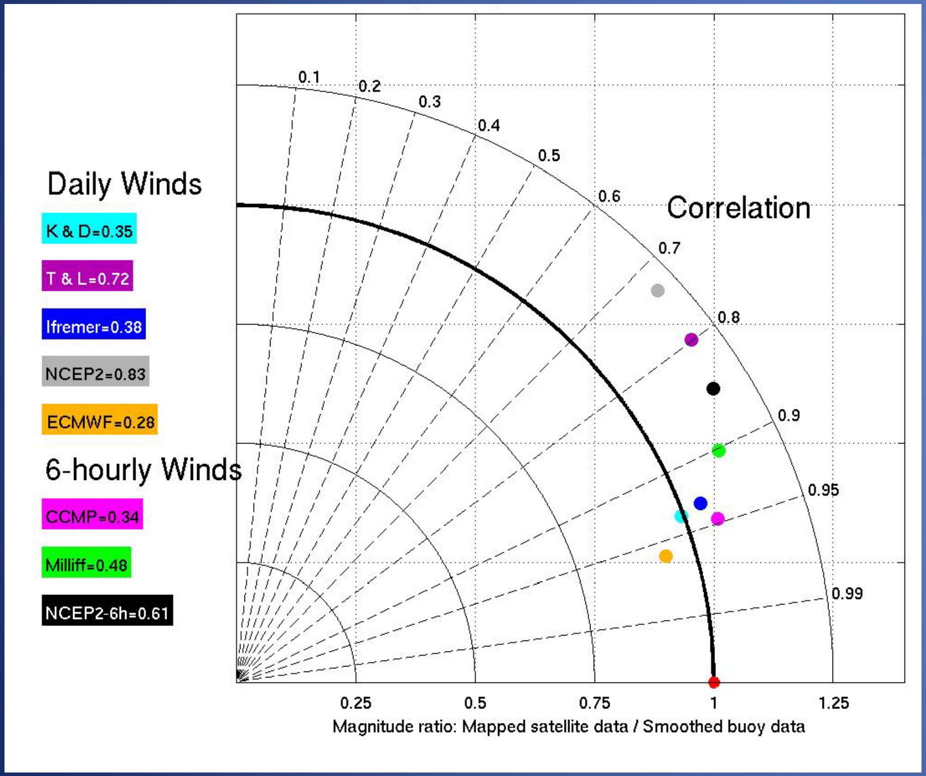


Pseudostress

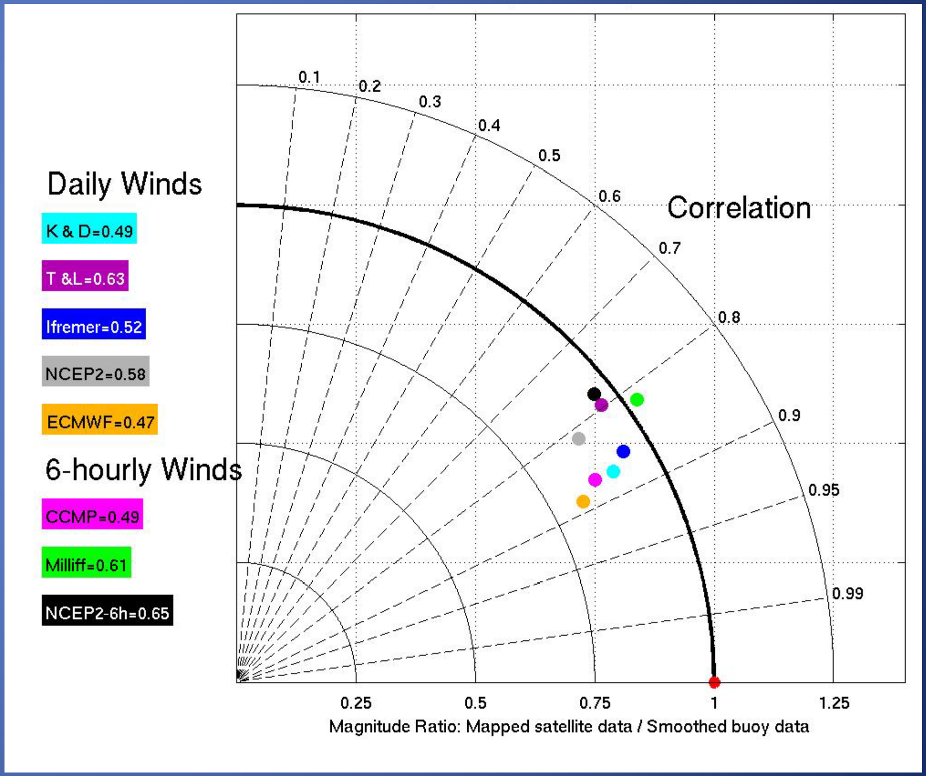


Taylor Diagram – Aegean Buoys
Daily and 6-hourly Winds

CLIMODE

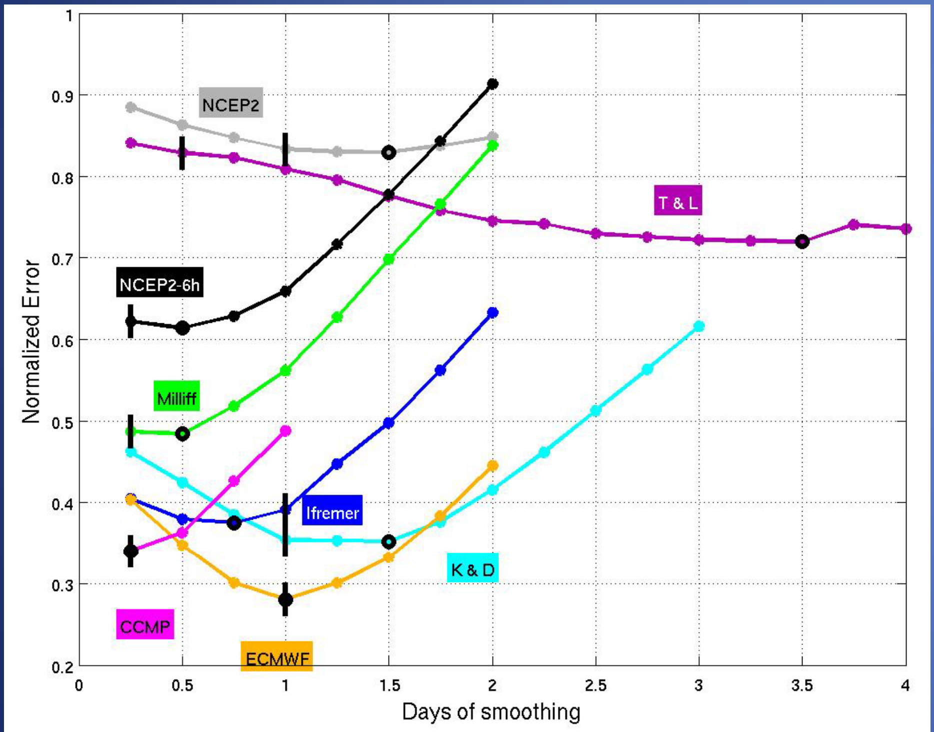


Aegean

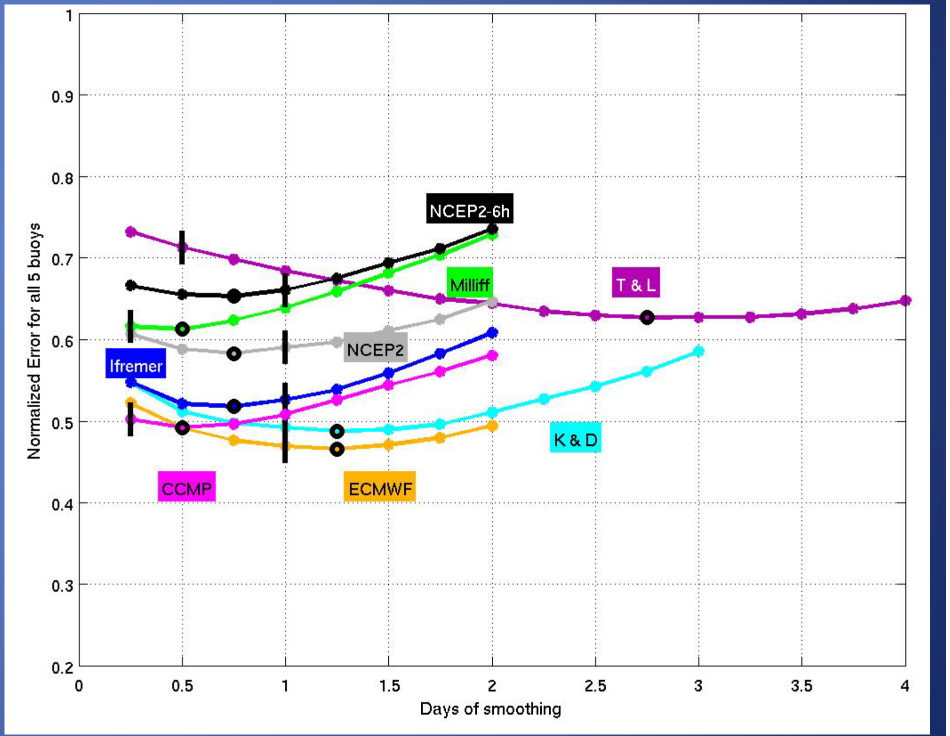


Normalized Error – Aegean Buoys
Daily and 6-hourly Winds

CLIMODE



Aegean



Conclusions

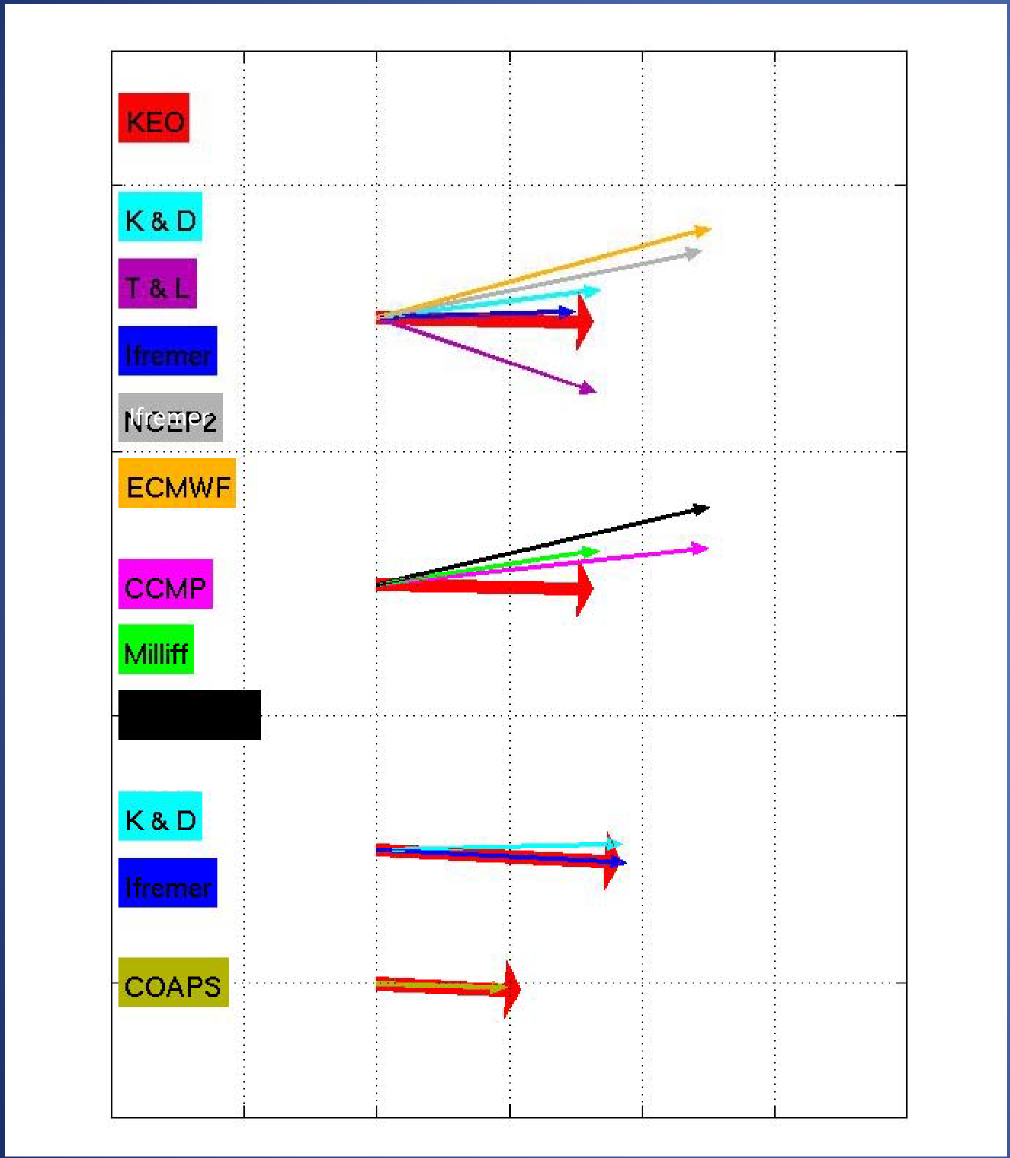
- Taylor diagram to represent both energy levels and correlation
- Determine temporal resolution of a particular product
- Metric robust with respect to different locations
- Based on buoy comparisons:

a) Best daily products: ECMWF, K&D, Ifremer

b) CCMP for 3-6-hourly product

- Next: test other products?
- Need other metrics such as spatial structure and derived fields

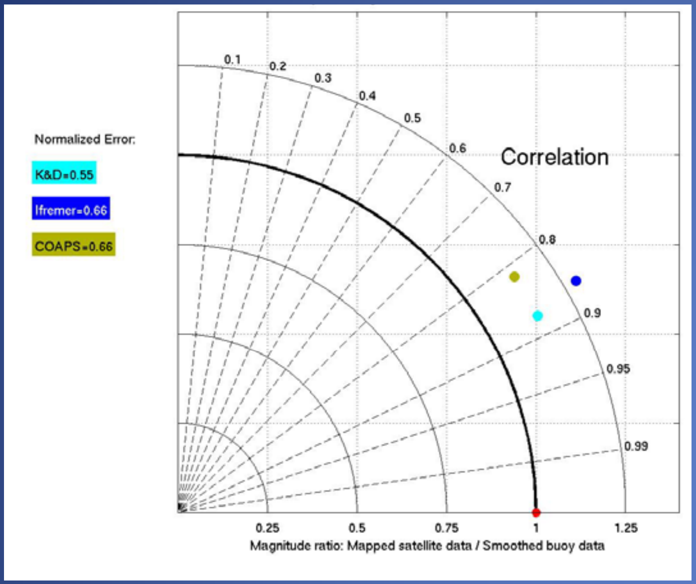
Mean Vectors – KEO Mooring



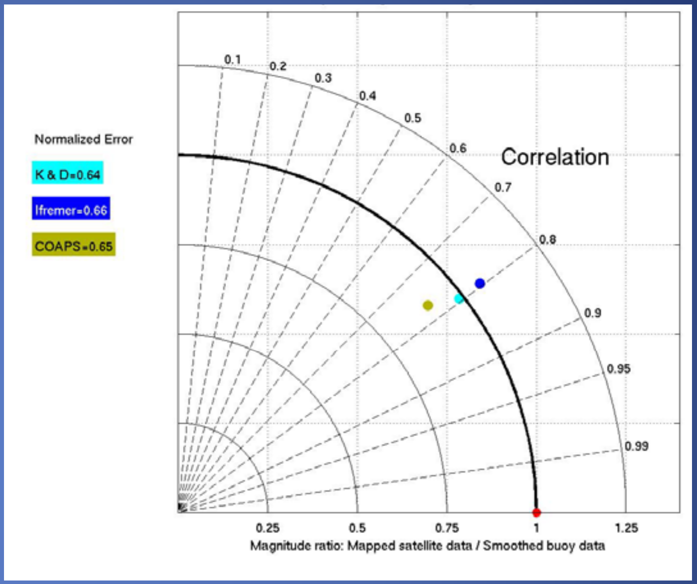
KEO Mooring winds weaker than GCMs and CCMP winds, (where CLIMODE speeds comparable)

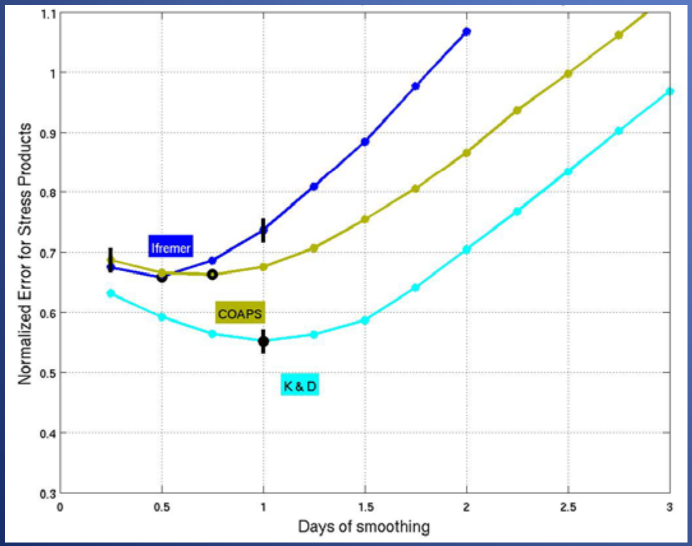
Stress Maps at Aegean Buoys

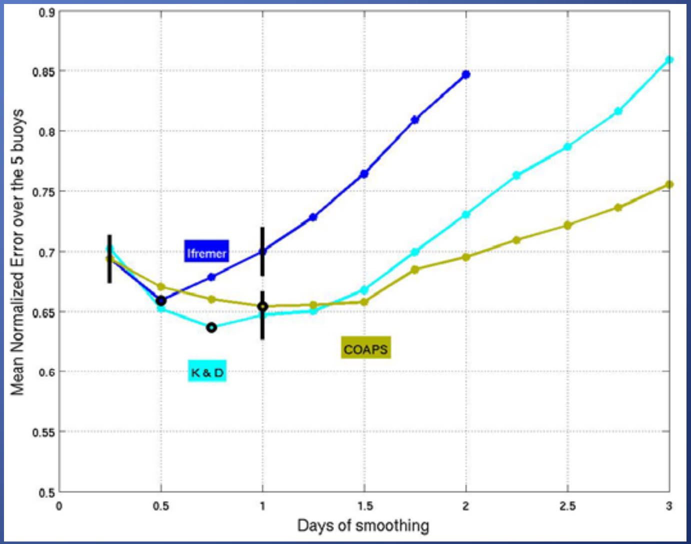
CLIMODE



Aegean



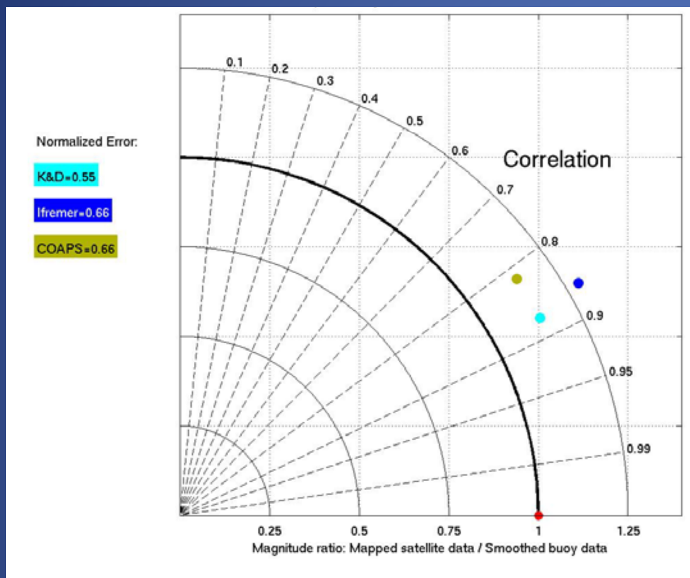


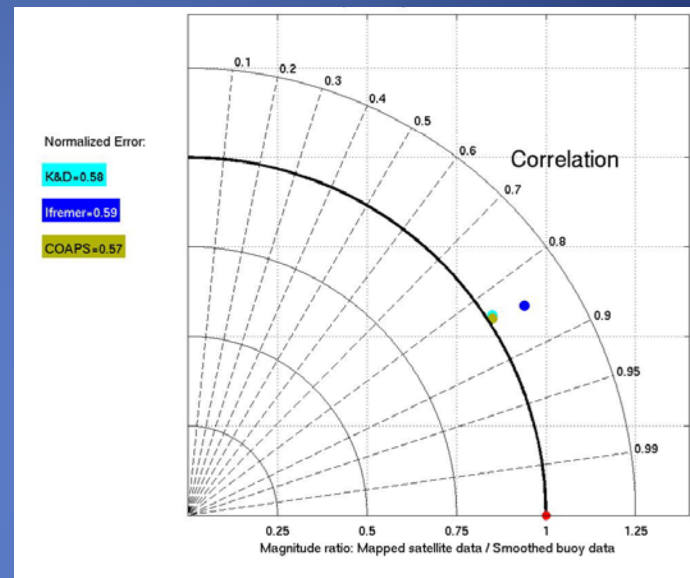


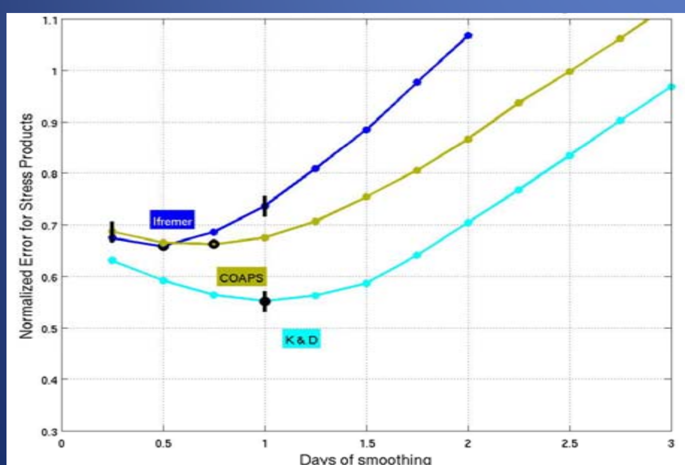
Stress Maps at KEO Mooring

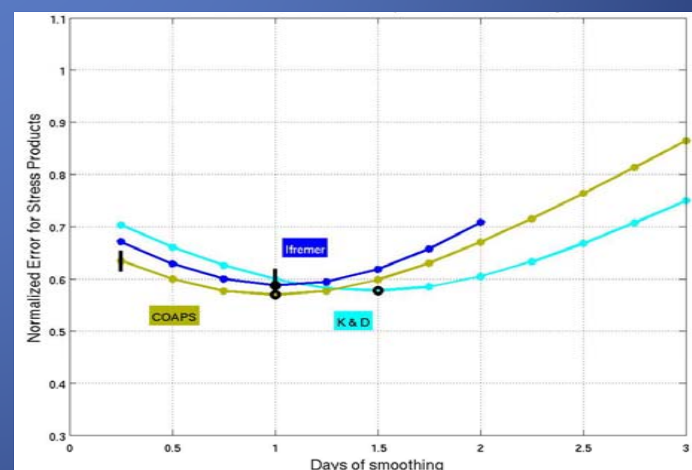
CLIMODE

KEO



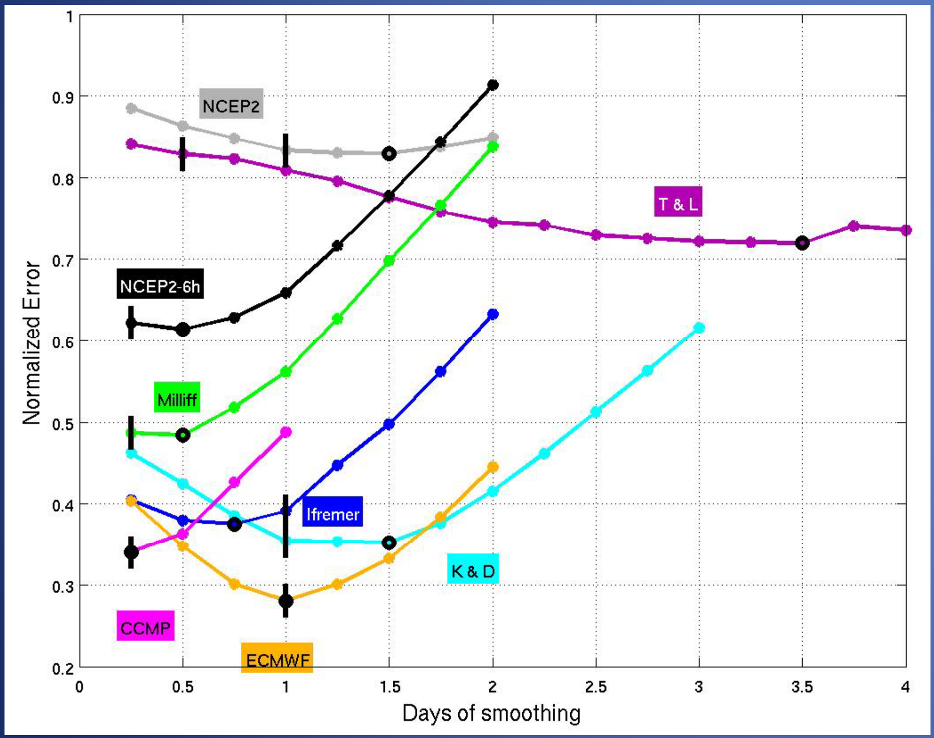






Normalized Error – KEO Mooring
Daily and 6-hourly Winds

CLIMODE



KEO