

Singularity analysis: a powerful image processing tool in remote sensing of the oceans

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Summary

- What is Singularity Analysis?
- What is it useful for?
- Conclusions
- Advertisements

What is Singularity Analysis?

Any technique capable to robustly assign a singularity exponent to each point in a image or map.

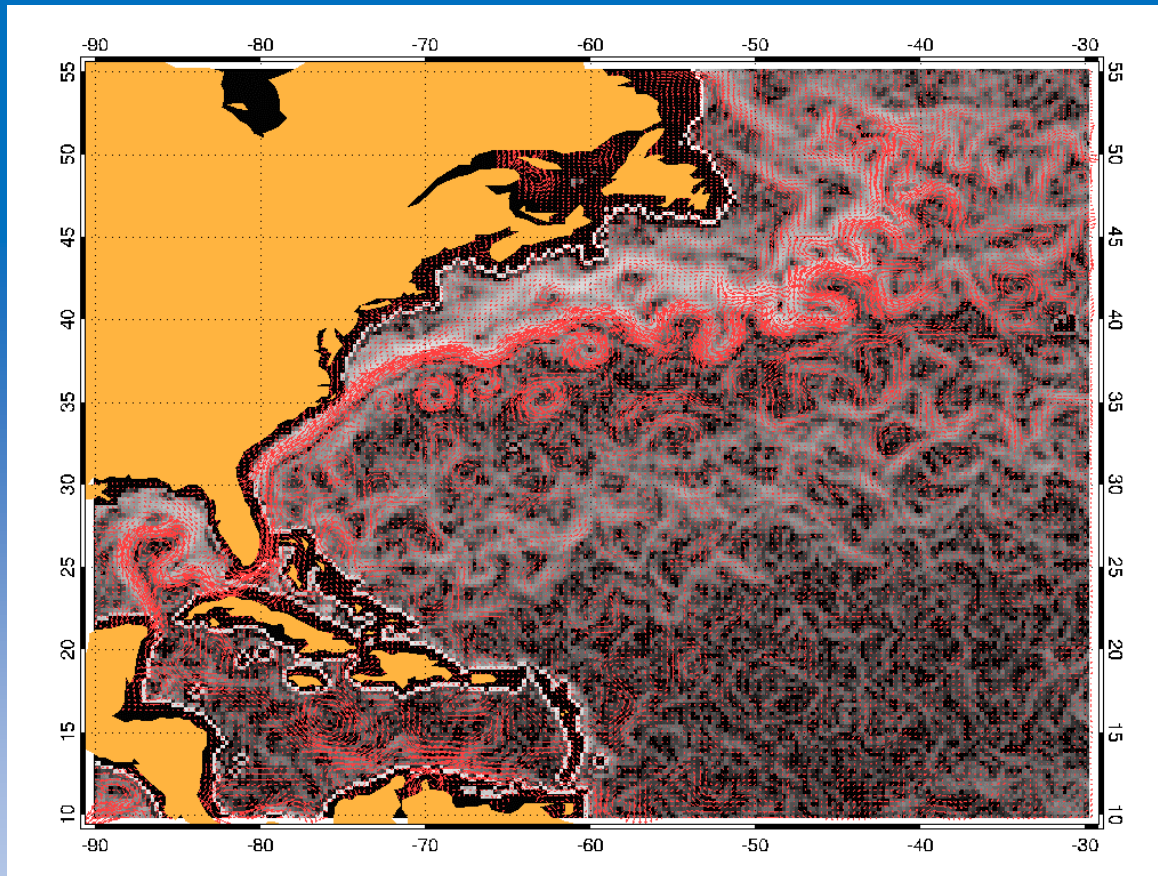
$$|\theta(\vec{x} + \vec{r}) - \theta(\vec{x})| = A(\vec{x})r^{H(\vec{x})} + o(r^{H(\vec{x})})$$

To deal with discretization effects, noise and long-range correlations the introduction of wavelet projections is necessary

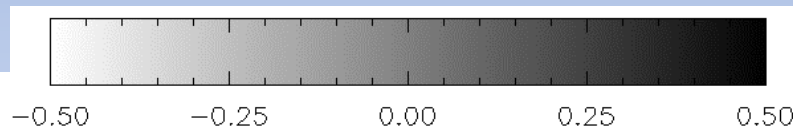
$$T_{\Psi}|\nabla\theta|(\vec{x}, r) \equiv \int d\vec{x}' |\nabla\theta|(\vec{x}') \Psi\left(\frac{\vec{x} - \vec{x}'}{r}\right) = \alpha_{\Psi}(\vec{x}) r^{h(\vec{x})} + o(r^{h(\vec{x})})$$

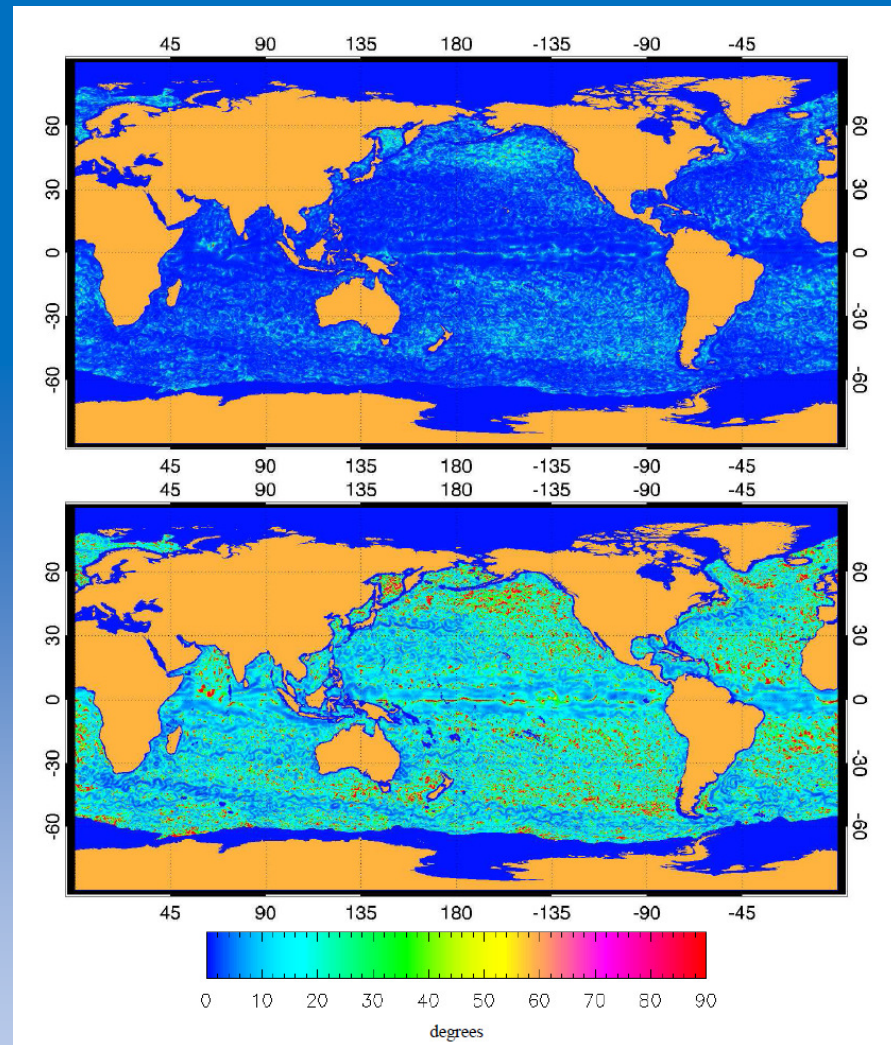
What is it useful for?

Singularity analysis tracks streamlines



Singularities derived from RSS MW SST product as compared with AVISO SURCOUF altimeter products

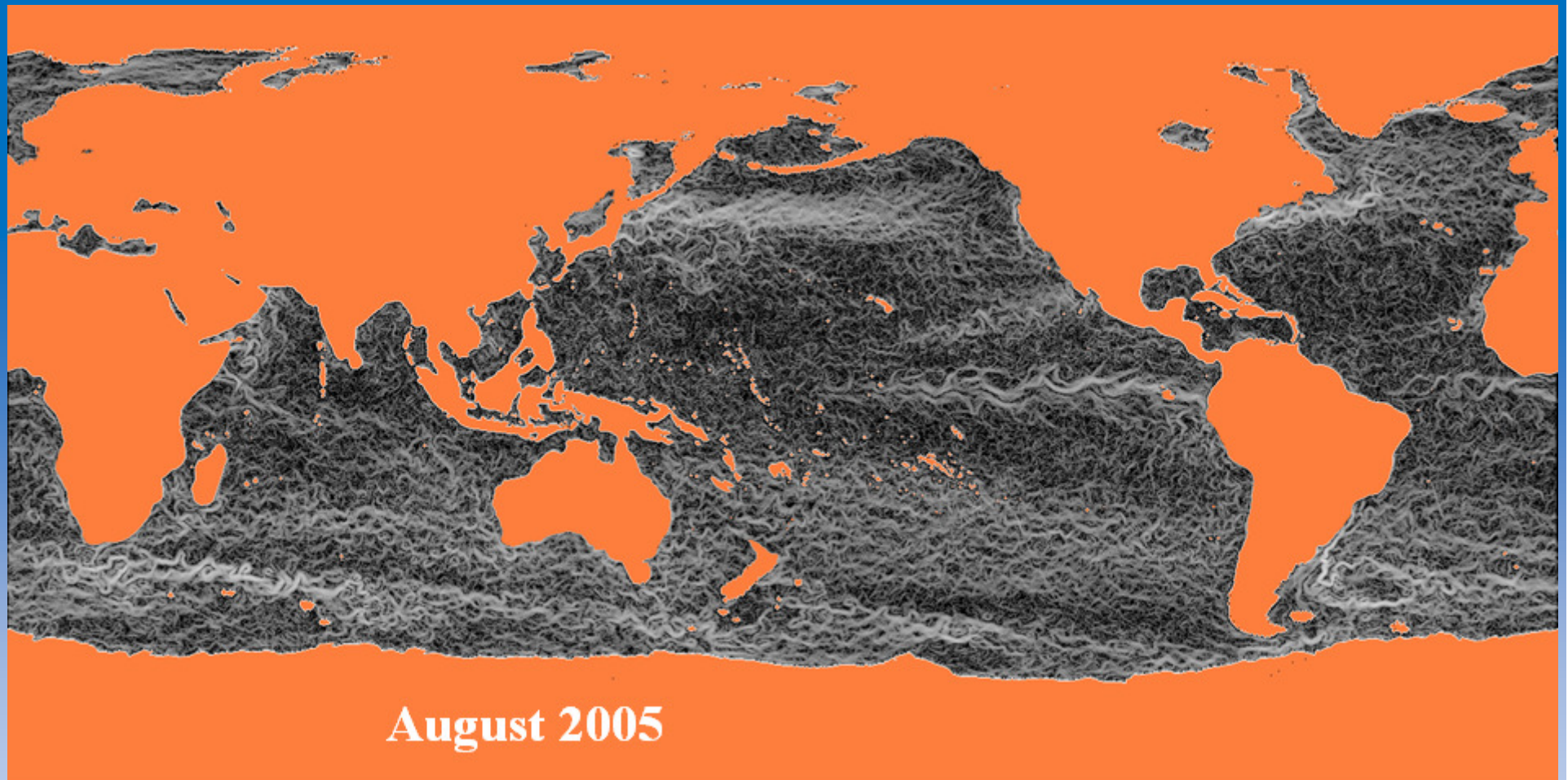




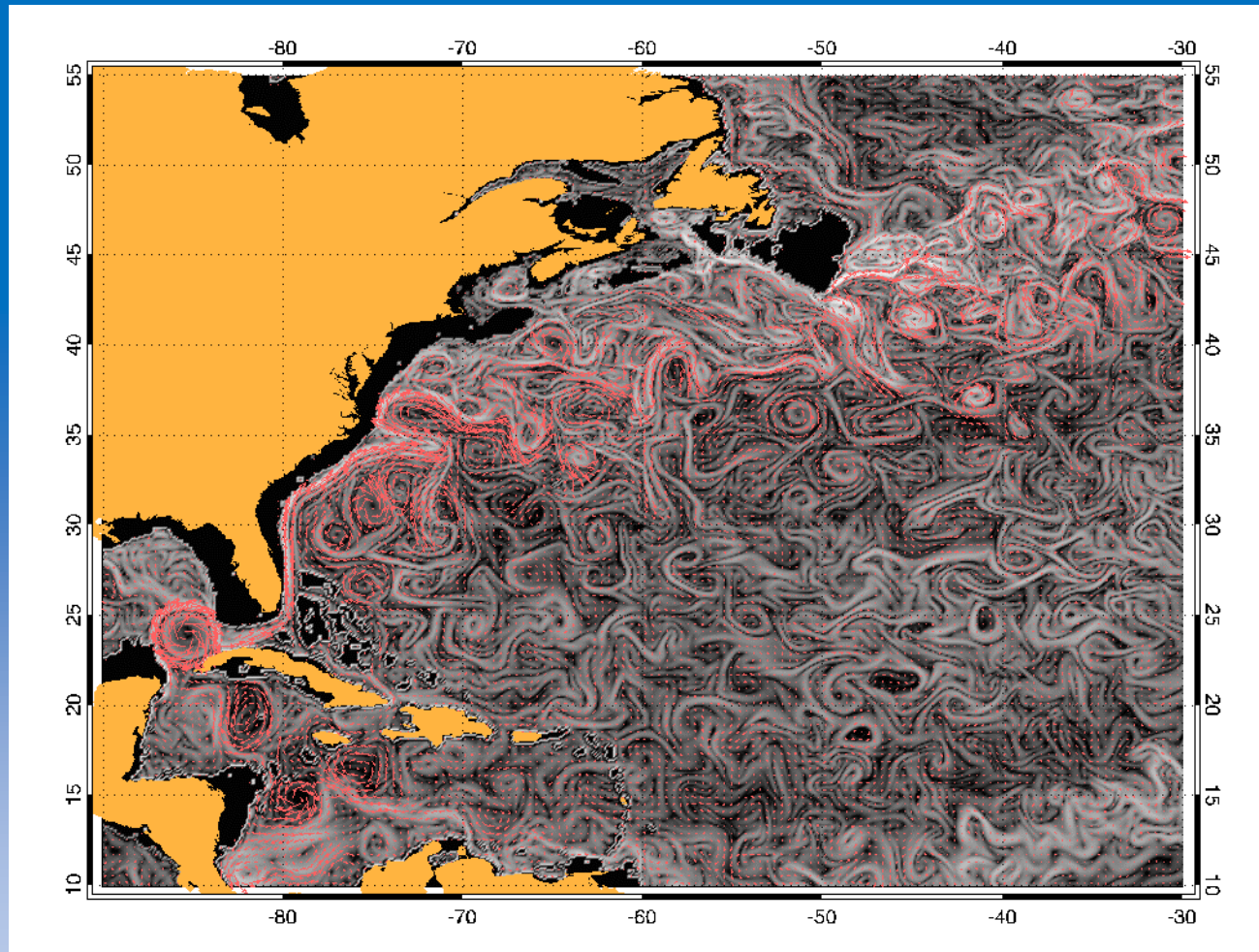
Angle between singularity lines (top, average: 3.4°) and isotherms (bottom, average: 22.5°).

Adapted from A. Turiel, V. Nieves, E. García Ladona, J. Font, M.-H. Rio and G. Larnicol, Ocean Sciences (2009)

Singularity analysis allows continuous tracking of streamlines



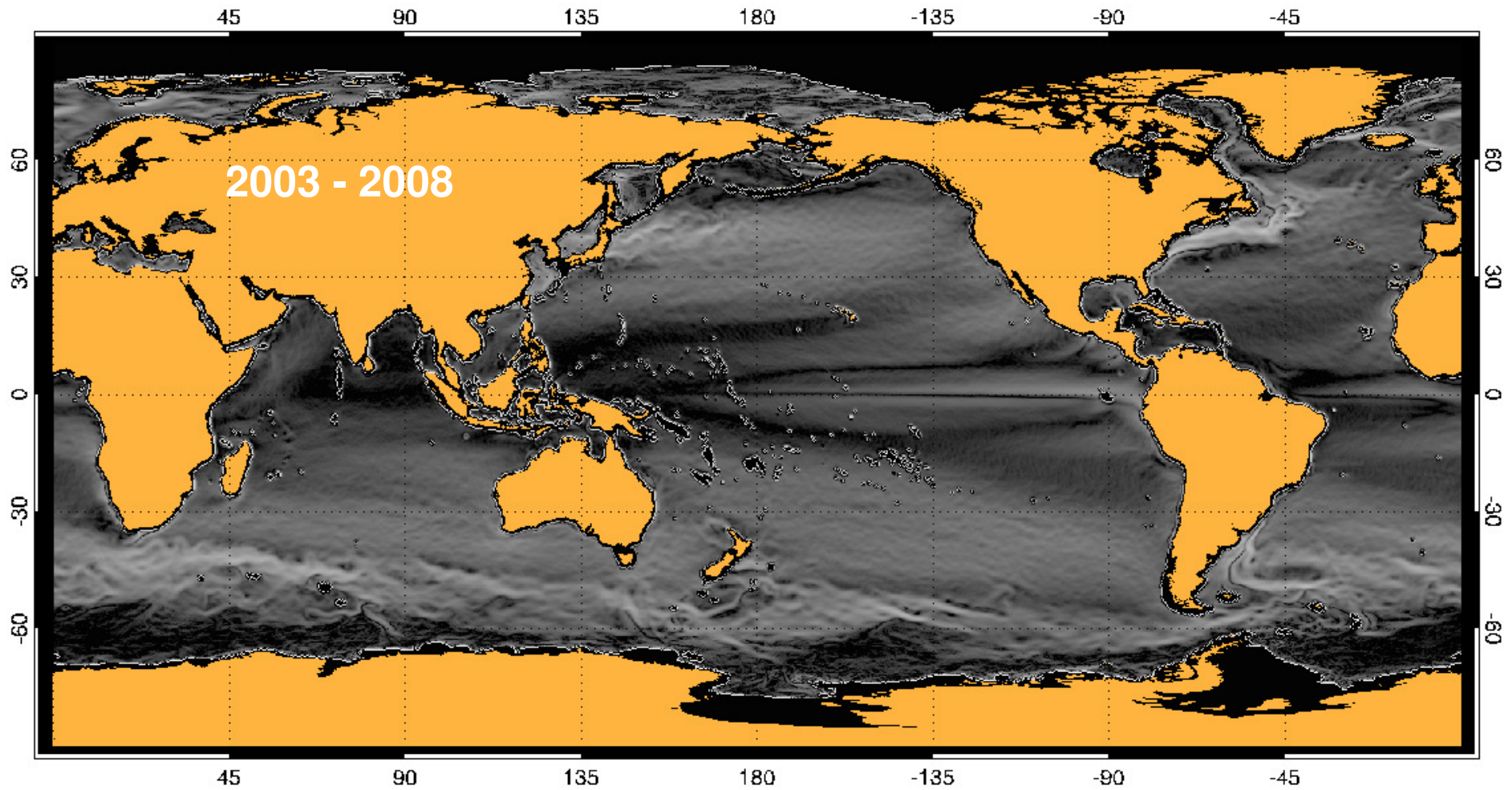
Assesment of the common phase structure



Singularity
analysis on Earth
Simulator at $z=97$
m (salinity and
temperature).

Collaboration with
IC3 (Jordi Isern-
Fontanet)

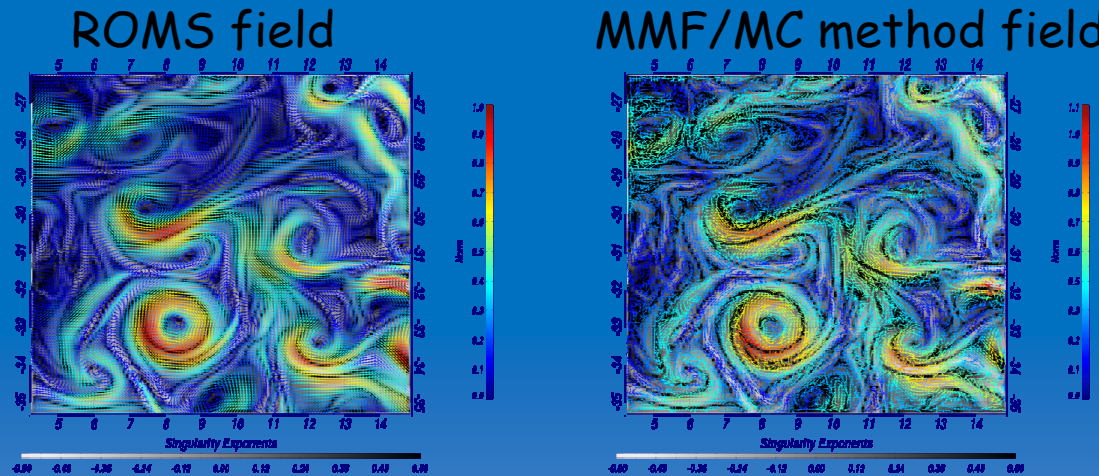
Persistence of phase statistics in climatic variables



Generation of high-resolution current fields

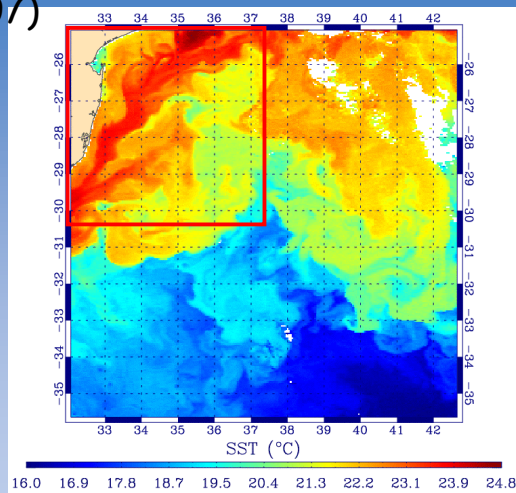
Results with ROMS data

Validation with 360 images of synthetic data from ROMS: comparison of the obtained motion field with the High Resolution (HR) motion field of ROMS (1/12°)

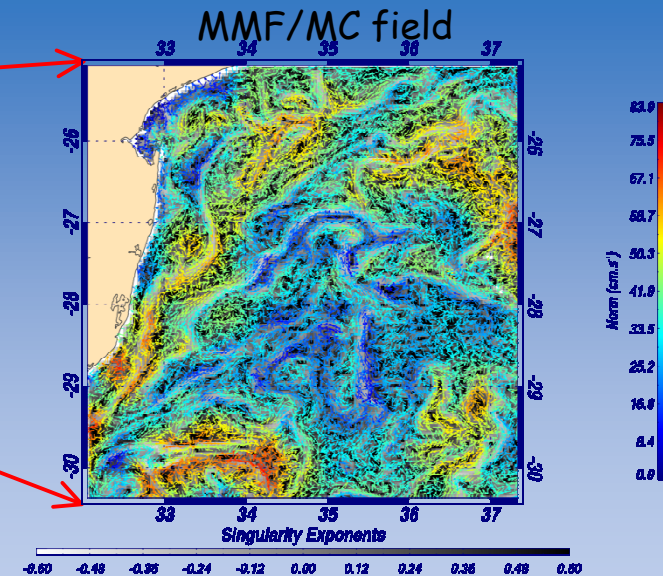
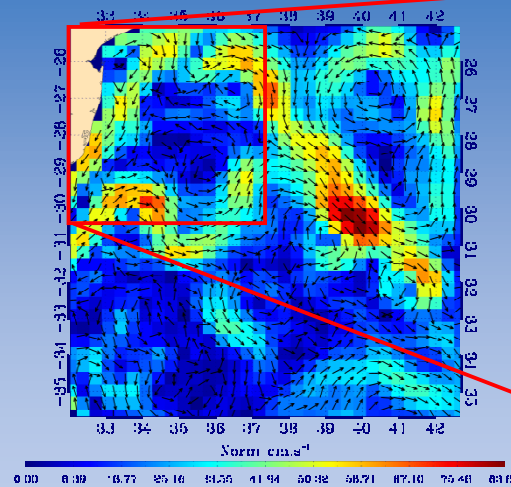


Results with satellite data

Modis-Aqua at 4km resolution SST (02/08/07)



GEKCO product collocated

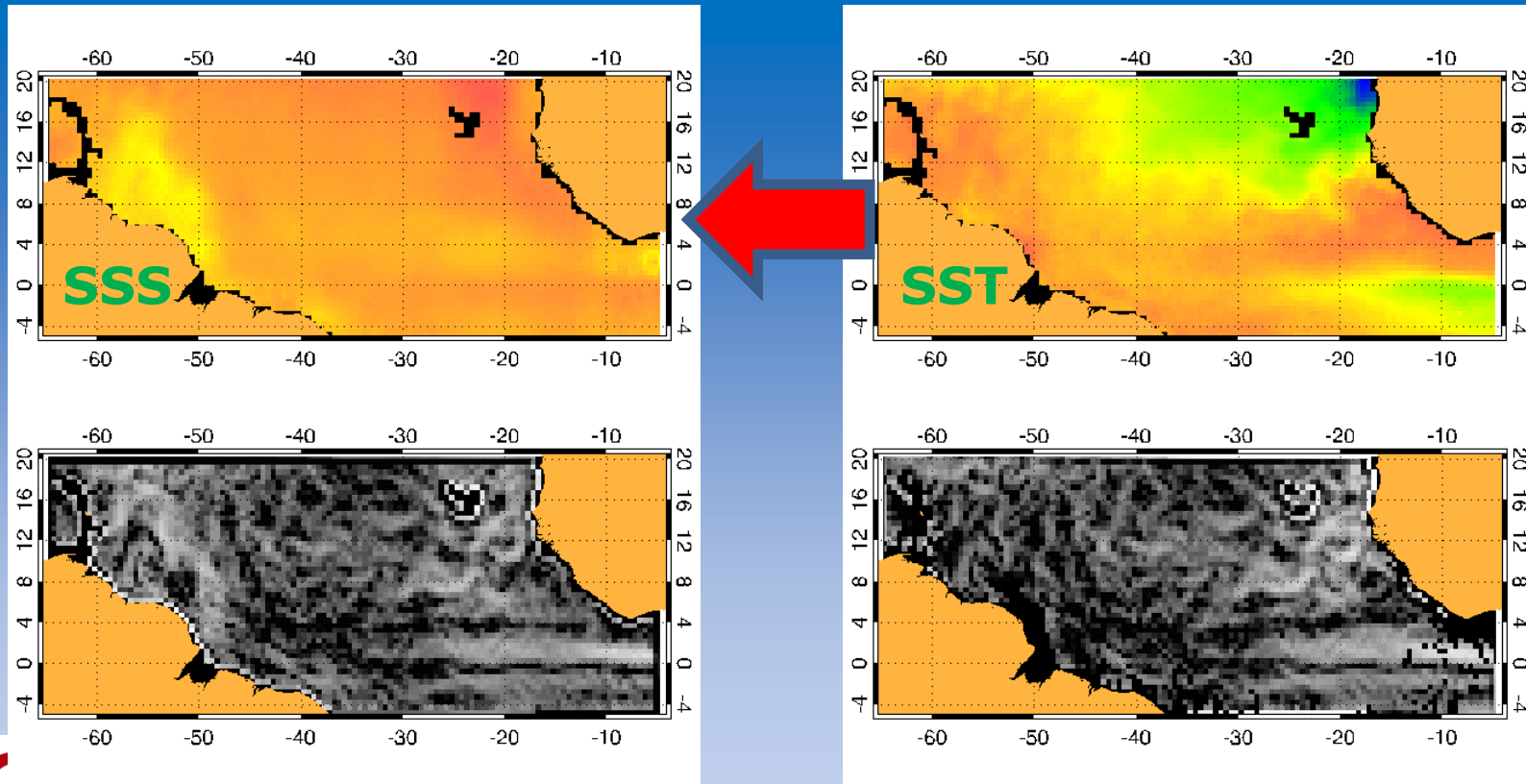


Singularity-based image blending (data fusion, L4 SMOS)

Product: 10-day averages binned, Full-from-Full EFoV.

Goal: Data fusion preserving singularities

Technique: Multiscale sources.

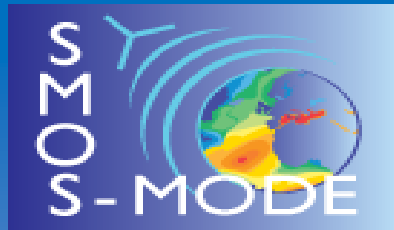


Conclusions

- Singularity analysis reveals the inner structure of flow currents from scalar maps.
- This implies a redundancy between scales than can be used to improve resolution and fill blanks.
- The commons singular structure allows a synergistic approach for data fusion without imposing any model.
- **Impact on user requirements:** Apart from space and time resolution, take care on the local effective bit depth!!

Advertisements

SMOS-MODE Annual Meeting
March 30, 2012, @ ESRIN



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Non-linear processes in Oceanic
and Atmospheric Flows 2012

July 3-6 2012, Madrid



<http://http://ifisc.uib-csic.es/nloa2012/>