High-Resolution Analysis Parameters from Simulated SST

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Summary ...

- Some infra-red sensors have **sub-km** resolutions. But smaller scale SST features tend to **evolve faster**. How should such high-resolution data be ingested into an L4 analysis?
- Indeed, **hourly, 1/48°-grid, global** SST field from the **ECCO2** ocean circulation simulation shows **sub-day** auto-correlation decay-periods for SST feature scales **smaller than 5 km**.
- The **MUR** L4 SST Analysis has been using a multi-scale analysis method with 11 different **"synoptic windows"** ranging from 48 to 12 hours, **chosen subjectively**.
- The ECCO2 SST auto-correlations suggest to decrease the MUR synoptic windows for the scales smaller than 5 km. The new **objectively determined** windows are found to reduce analysis error.

ECCO2 ocean simulation ...

"Estimating the Circulation and Climate of the Ocean, Phase II"

Project website: **http://ecco2.org/**

The "LLC4320" simulation: 1/48° grid, 90 vertical levels with 1-m thick surface level, 6-hourly 0.14° ECMWF analysis forcing, atmospheric load, tides, dynamic ice model, etc.

image shows the velocity magnitude

SST "truth" fields: global 1/48° × 1/48° grid, hourly in December 2011.

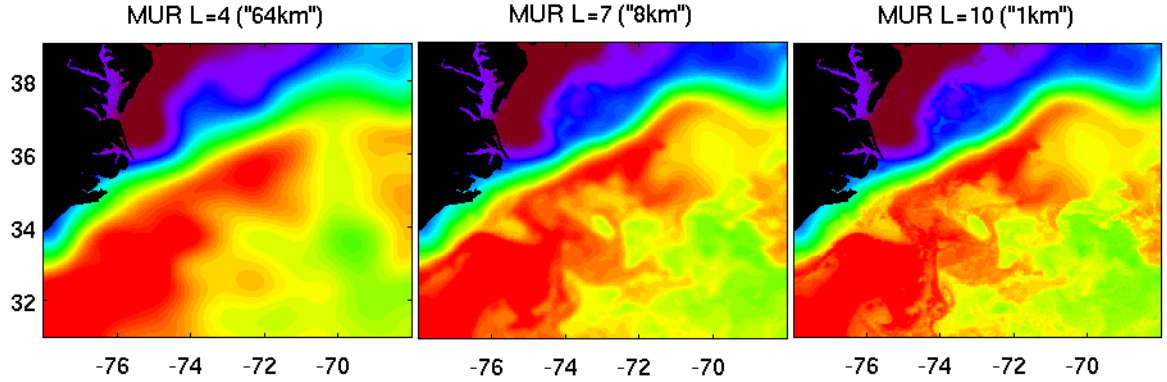
Simulated L2P pixels: MODIS-T, MODIS-A, AMSR-E (2010); only "highest quality" flagged locations (no cloud) are used to sample the truth fields.

MUR L4 Analysis ...

MODIS, AVHRR, microwave, & in-situ SST data on a 1-km grid.

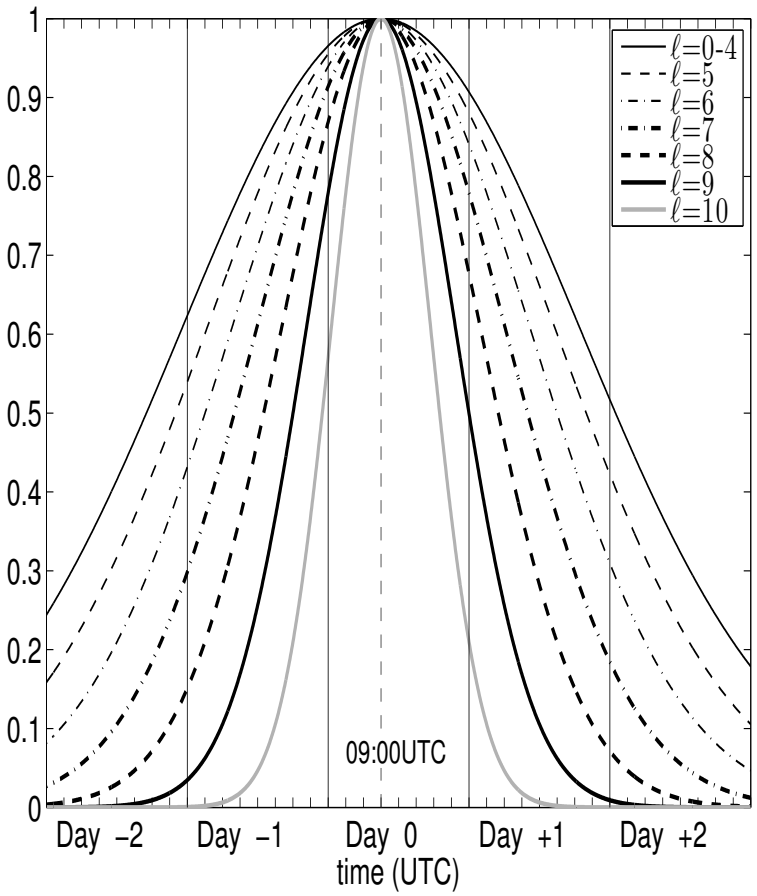
Chin et al (2017) *Remote Sensing of Environment* 200: 154-169.
10.1016/J.RSE.2017.07.029

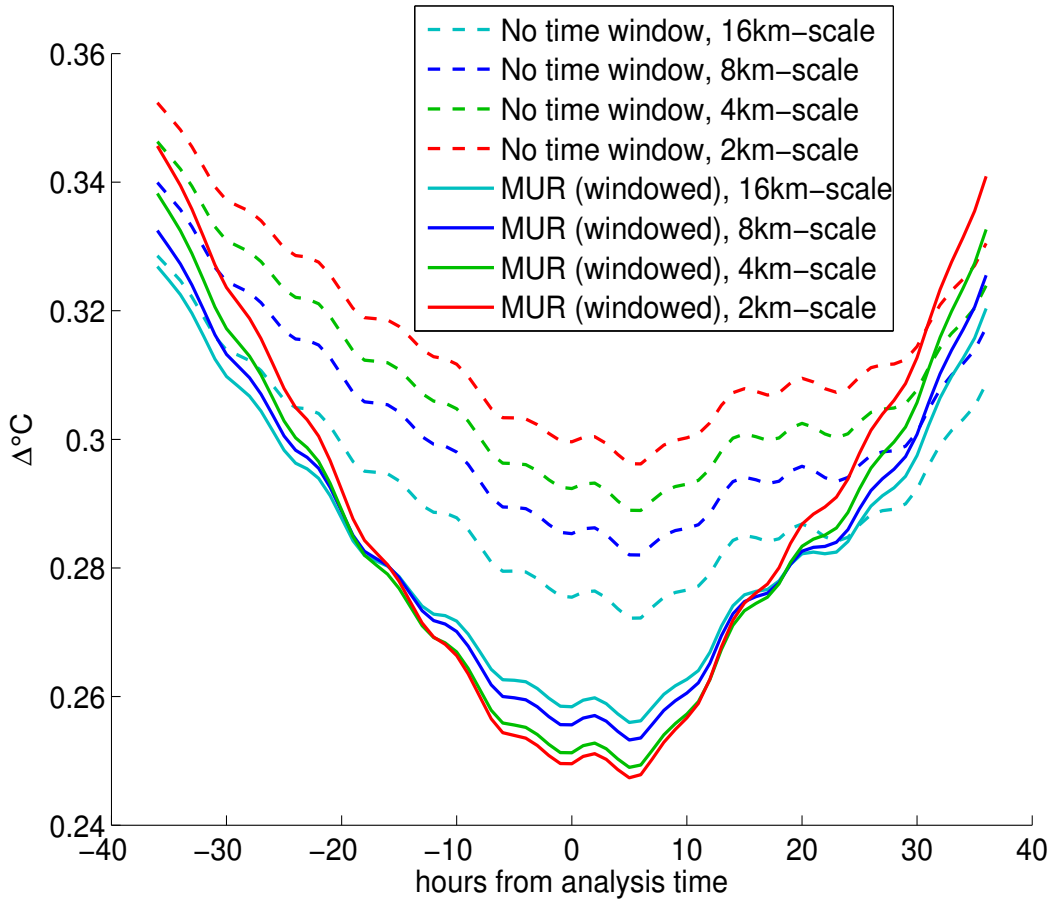
Multi-Resolution Variational Analysis (wavelet decomposition) is used to set different **synoptic windows** for different scales:



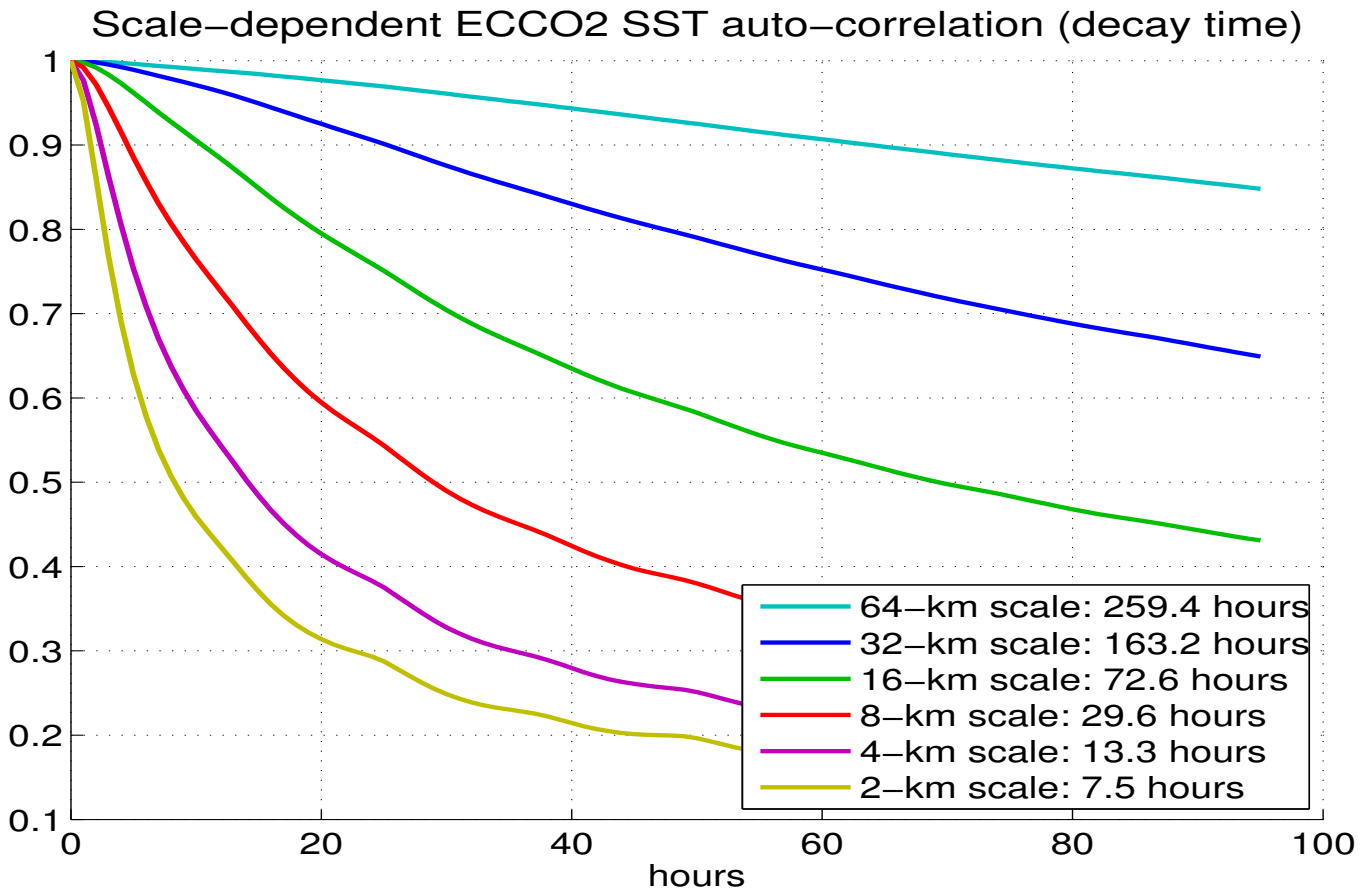
scale index (ℓ)	scale length (Δ_ℓ)		wavelet grid dimensions	synoptic window (τ_ℓ)	new τ_ℓ from ECCO2
	degrees	km			
4	0.703	78.2	512 × 256	48 hours	260 hours
5	0.352	39.1	1024 × 512	42 hours	163 hours
6	0.176	19.5	2048 × 1024	36 hours	72 hours
7	0.088	9.77	4096 × 2048	30 hours	30 hours
8	0.044	4.89	8192 × 4096	24 hours	13 hours
9	0.022	2.44	16384 × 8192	18 hours	8 hours
10	0.011	1.22	32768 × 16384	12 hours	—

Use of **scale-dependent synoptic windows** (left figure) reduces analysis error at all scales (right figure: ECCO2-simulated L2P data were analyzed *with [solid lines]* and *without [dashed lines]* scale-dependence in window lengths):





SST Autocorrelation from ECCO2

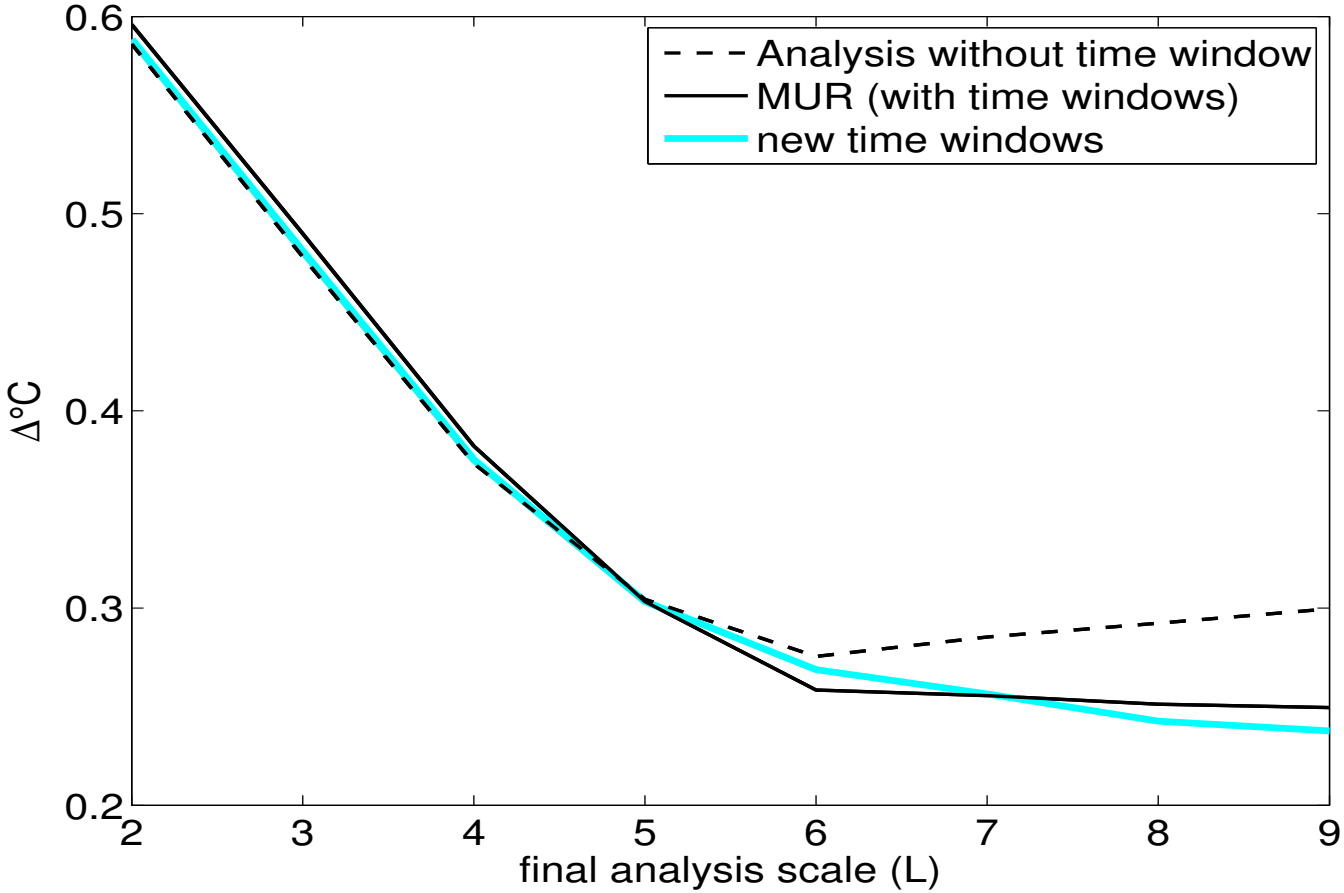


- $\leq$ 5 km-scale SST features are <u>not</u> "synoptic" (temporarily correlated not well enough) for <u>daily</u> analysis.
- Sub-day time-windows for input L2P data are appropriate for analyzing at such scales.

"MUR Analysis" of ECCO2-simulated L2P data

Simulated L2P data from MODIS-T, MODIS-A, AMSR-E cloud-free pixel locations are analyzed using MUR's multi-resolution method.

Analysis error (against the ECCO2 "truth" SST fields) for three cases differing only by syoptic window durations (τ_ℓ):



- High-resolution data could *increase* errors without synoptic windows (dashed curve).
- Window parameters determined from ECCO2 autocorrelation have resulted in the smallest analysis error at the finest scale (blue curve).

Conclusion ...

- ECCO2 (**fully global, 2 km grid, hourly**) SST field is found to be a uniquely valuable asset for developing and testing high-resolution analysis methods:
  - *parameters based on (modeled) SST dynamics*,
  - *analysis system simulation experiments (with truth field).*
- Synoptic window parameters in MUR L4 analysis are refined objectively using ECCO2 SST. The new parameters are shown to reduce analysis error. (They will be used in a future MUR version, which also plans to ingest VIIRS SST data.)
- Scale-dependent **synoptic window length** is desirable to balance *spatial coverage* against *aliasing*; window of **less than a day long** is found appropriate for scales finer than 5 km.