The West Coast Ocean Forecast System (WCOFS)

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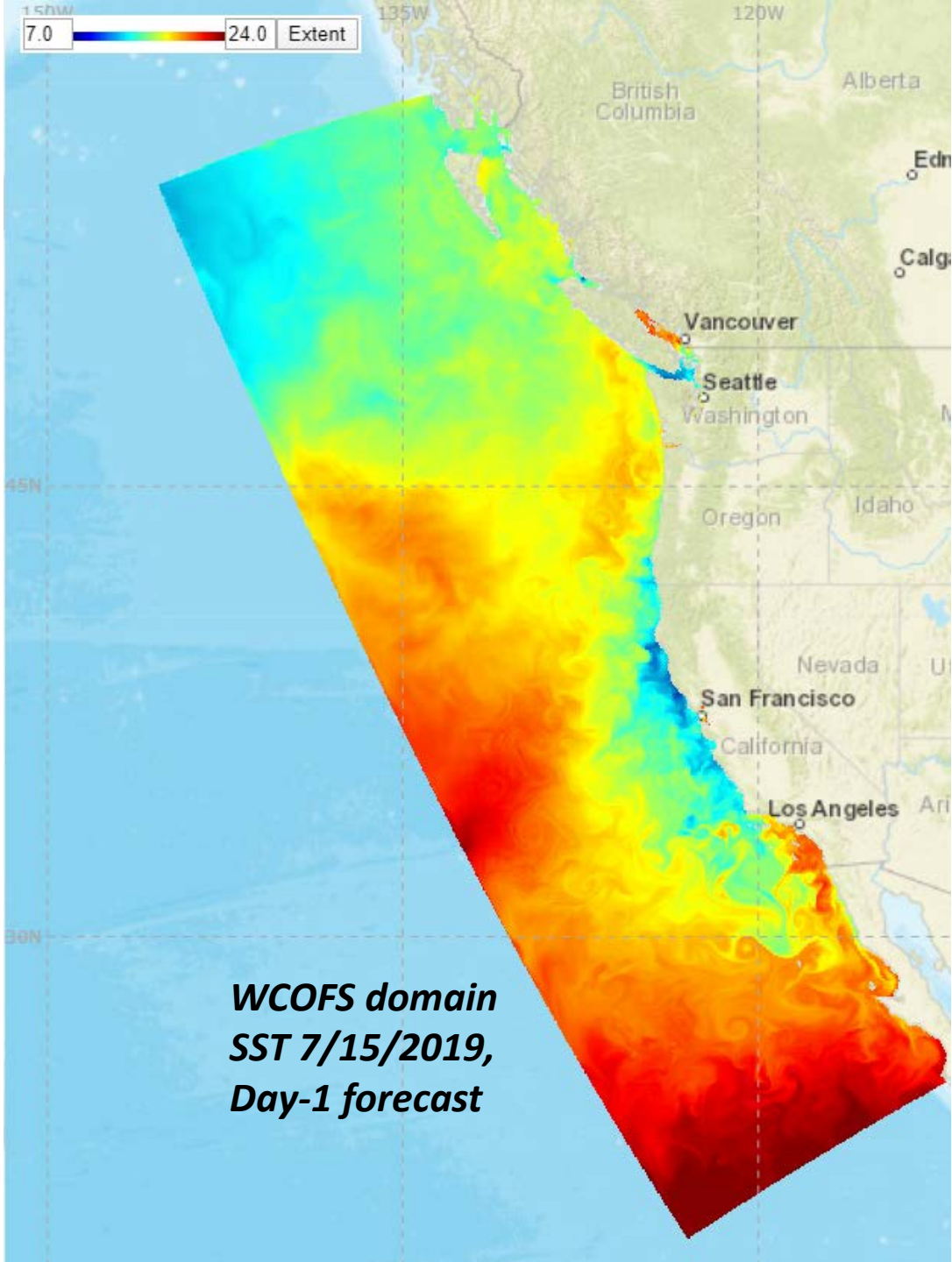
WCOFS: a regional ocean forecast system [transition to operations at NCO: FY21]

Prediction goals: 72-hr forecasts of coastal currents, temperature and salinity fronts, total coastal sea level etc.

Based on Regional Ocean Modeling System (**ROMS**)

Data assimilation: 4DVAR (satellite SST and altimetry, surface currents from HF radars). @ 4-km horizontal resolution

In addition: Higher resolution (2-km) multiyear simulations without assimilation: skill assessments, basic research on seasonal and interannual variability (relevant to fisheries)



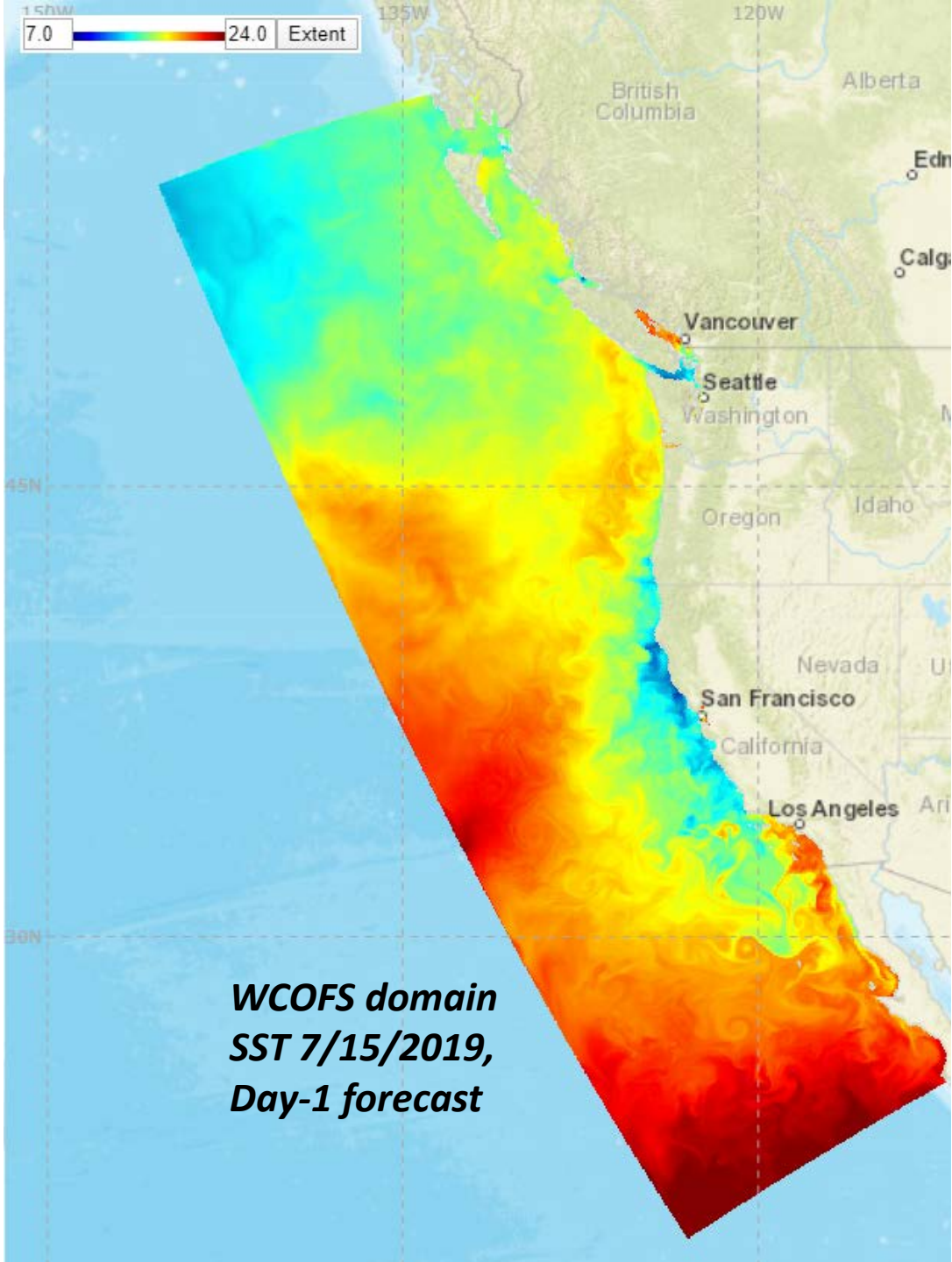
Area dynamics:

- Three-dimensional, baroclinic, nonlinear
- Summer wind-driven upwelling (seasonal cold front, strong coastal currents, ecologically productive area, commercial fishing)
- Anomalies driven by El Nino

ROMS:
- 4 km horizontal resolution (real-time forecast system)
- 40 vertical layers (terrain-following)

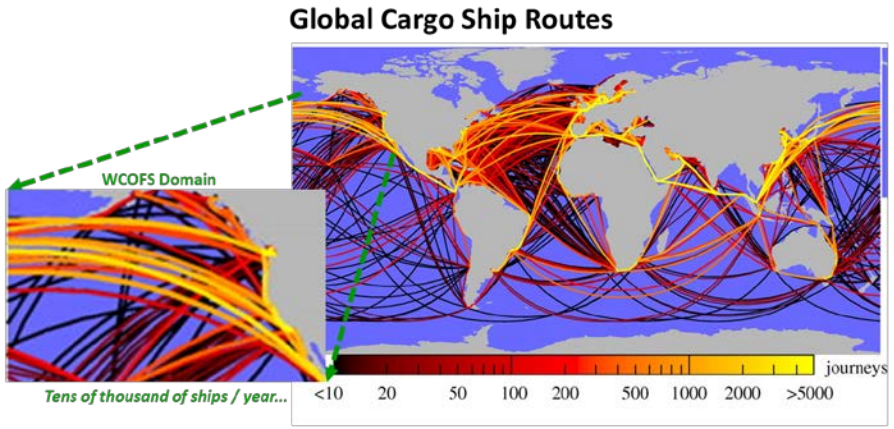
Atmospheric forcing: NOAA NAM @ 12 km res. [wind velocity, net shortwave radiation, downward longwave radiation, air temperature, air pressure, relative humidity, rain rate]

Oceanic boundary conditions:
- Non-tidal: G-RTOFS (NOAA NCEP)
- Tidal: OTIS (Egbert and Erofeeva, Oregon State U.)



Users and uses:

- Navigation (commercial ship routing... fuel conservation): surface currents
- Fisheries (commercial/recreational): fishing operation planning (SST fronts, surface mixed layer depth, currents... e.g., crab pots retrieval)
- Environmental hazard response & search and rescue (surface flow trajectories)
- Ocean circulation forecasts are a base for coupled biogeochemical models (hypoxia on the shelf), pathogen predictors (harmful algae blooms), etc.
- Total water level: e.g., beach flood / erosion warnings
- Boundary conditions for higher resolution coastal ocean, estuarine, nearshore models



All cargo ships > 10,000 GT during 2007, plus tankers and bulk ships (less regular routes)

Kalusa *et al.*, J. R. Soc. Interface (2010)

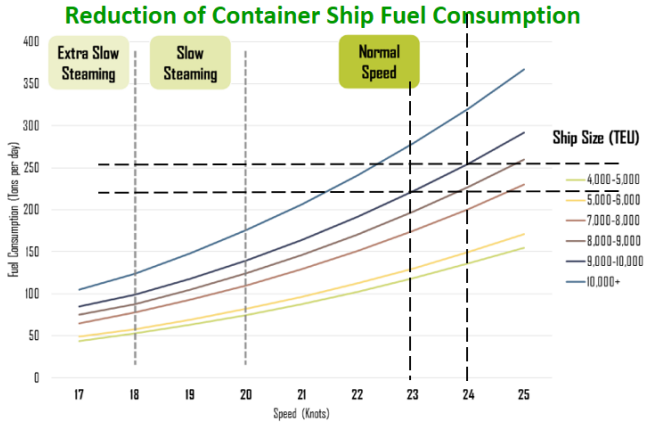


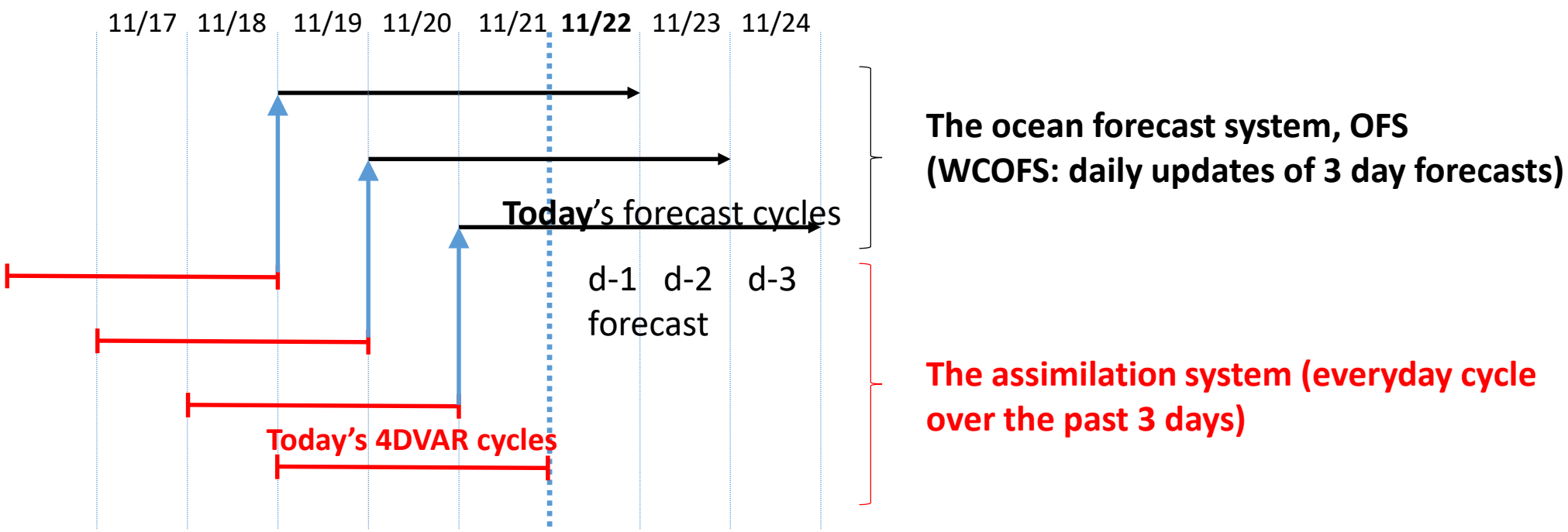
Diagram from:
Notteboom, T. and P. Carriou (2009) "Fuel surcharge practices of container shipping lines: Is it about cost recovery or revenue making?". Proceedings of the 2009 International Association of Maritime Economists (IAME) Conference, June, Copenhagen, Denmark.

- https://people.hofstra.edu/geotrans/eng/ch8en/conc8en/fuel_consumption_containerships.html

Image courtesy of PIL

4DVAR implementation:

- Daily, in 3-day windows
- Initial conditions are corrected

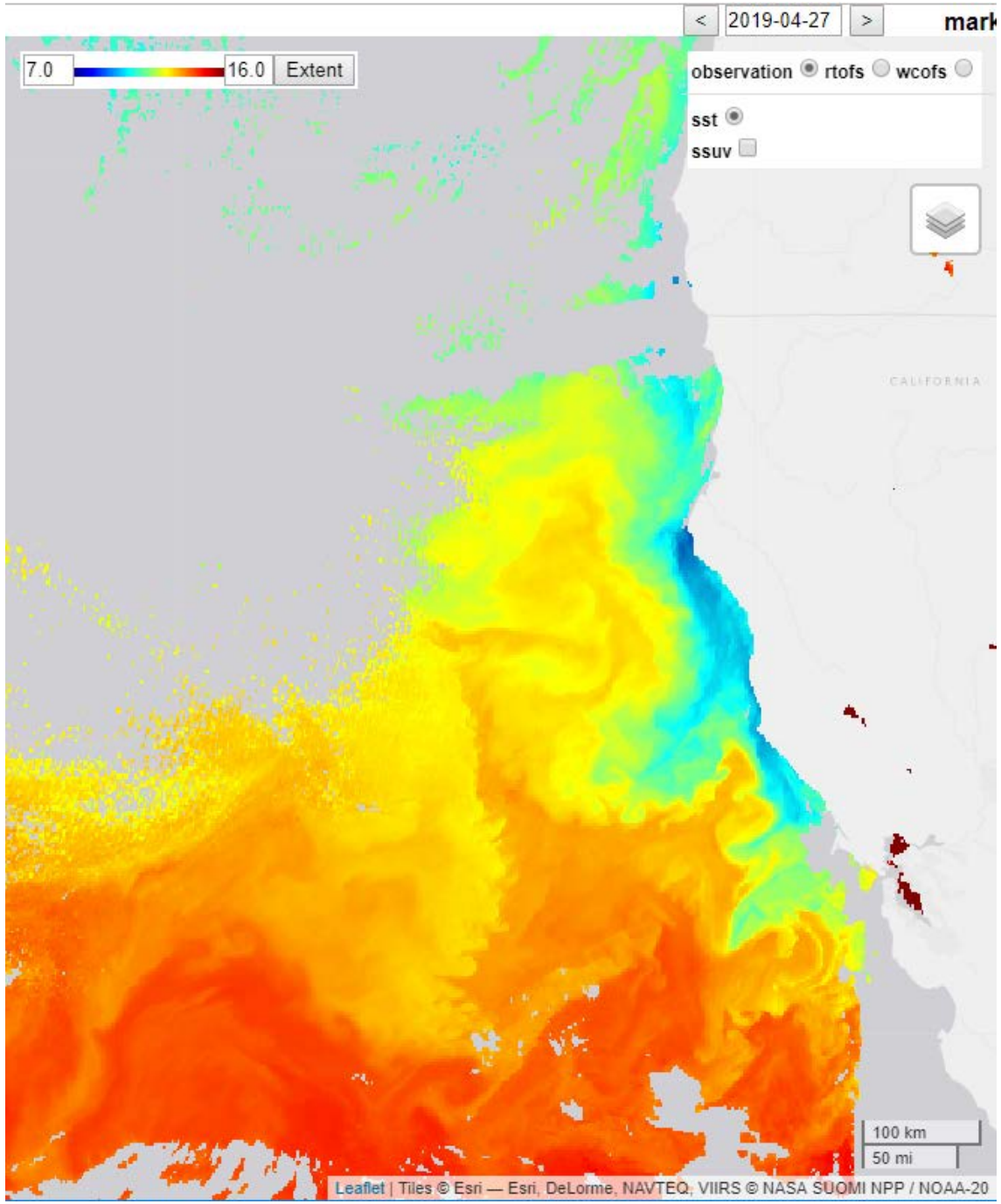


4DVAR:

- Uses the tangent linear and adjoint ROMS components
- Provides dynamically based time and space interpolation of sparse and noisy data sets

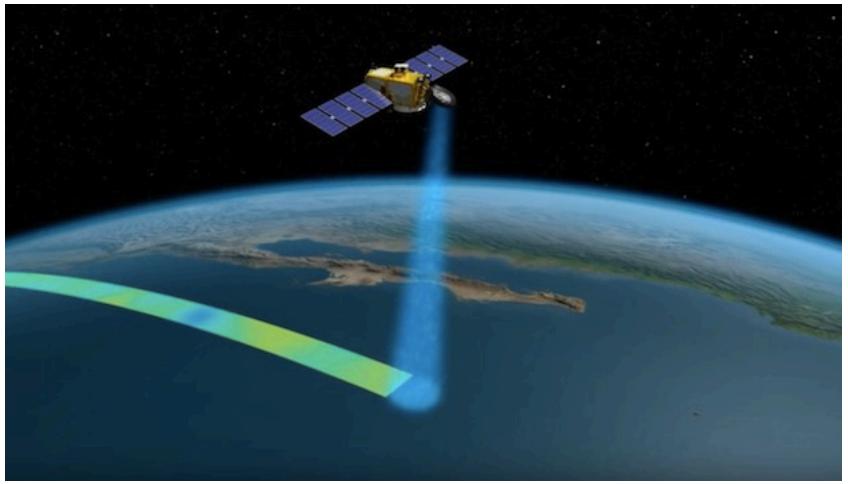
Assimilated data (1): Satellite SST

NPP VIIRS
NOAA20 VIIRS
GOES-17



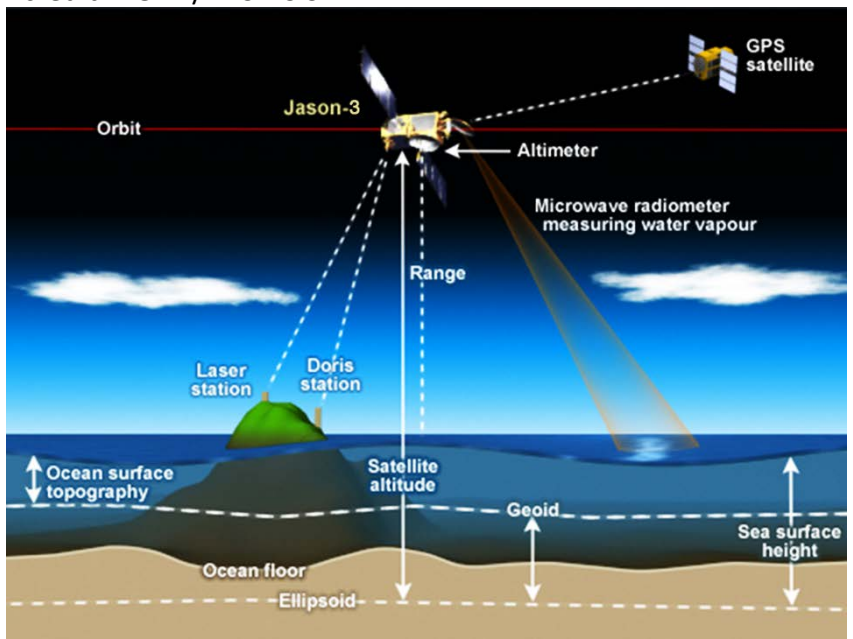
(a mosaic of nightly SST passes of Central and Northern California from NPP VIIRS, 27 Apr 2019)

Assimilated data (2): Altimetry



credit: NASA

credit: NOAA/NESDIS STAR

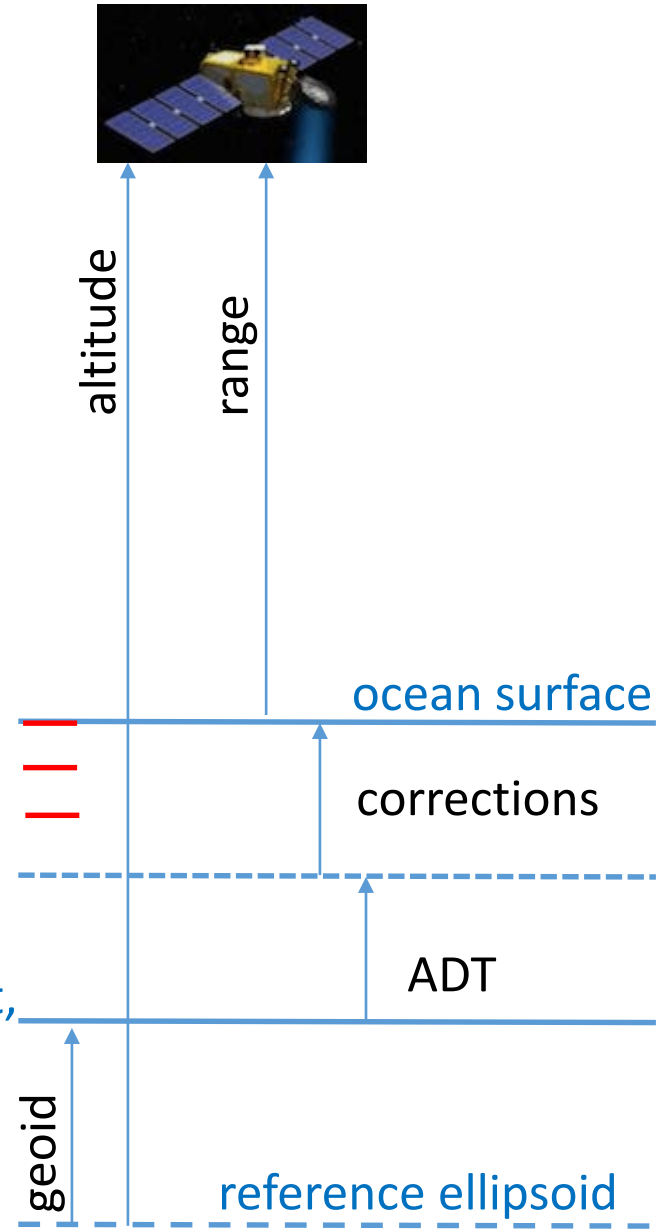


"corrections": wet tropo, tides, barometric pressure

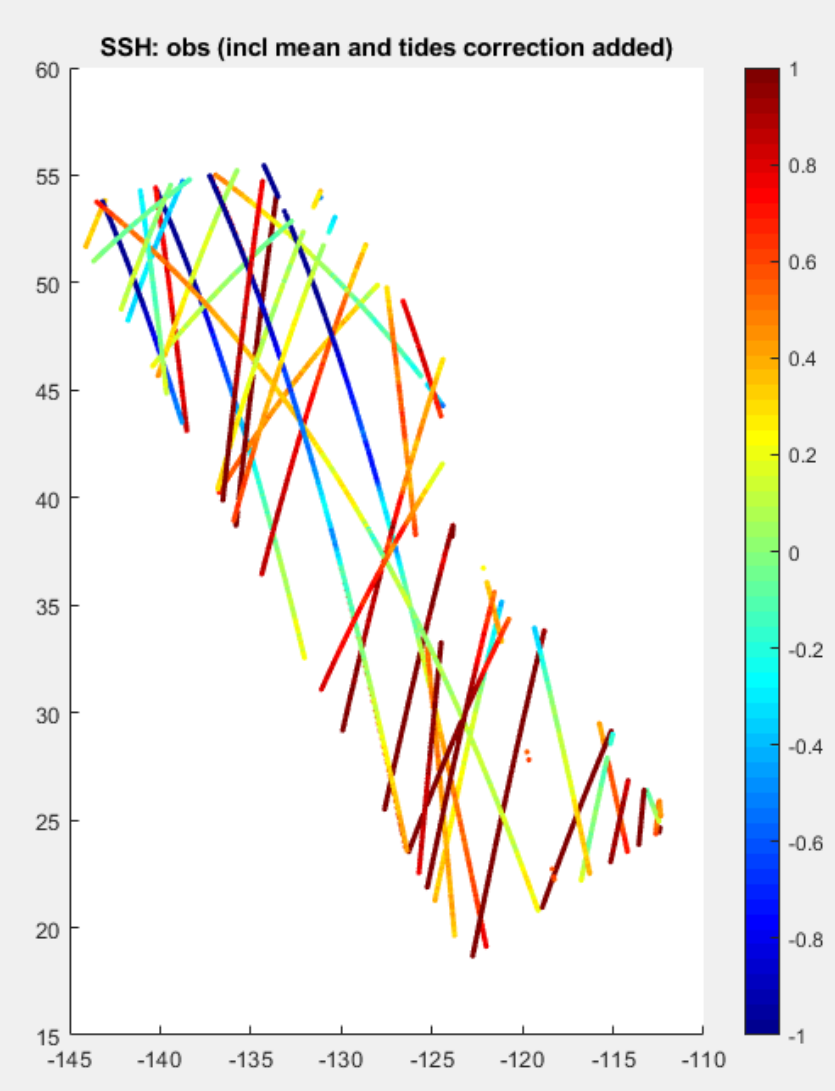
geoid (if the ocean were at rest, its surface would be a geoid)

ADT=Absolute Dynamic Topography

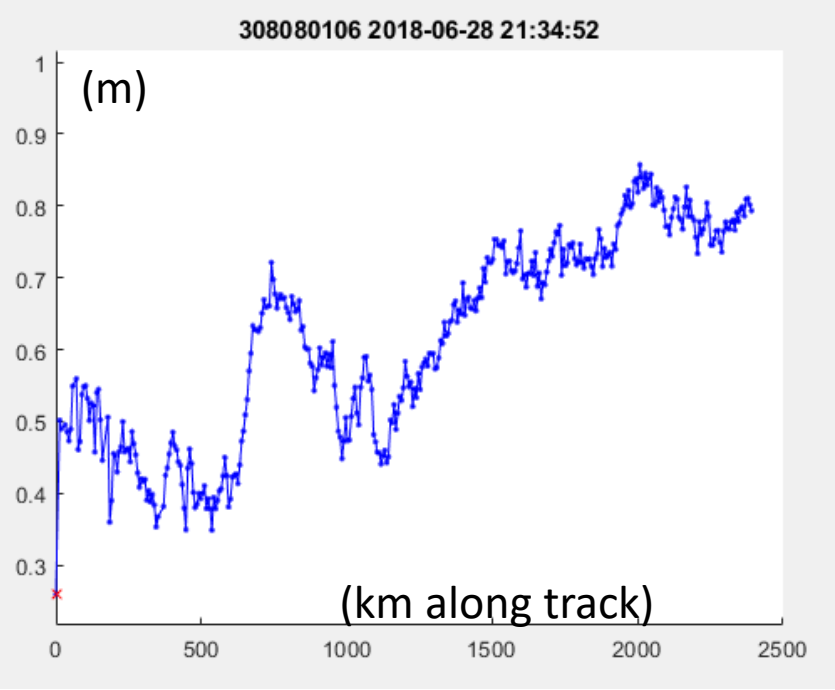
ADT = MDT + SLA

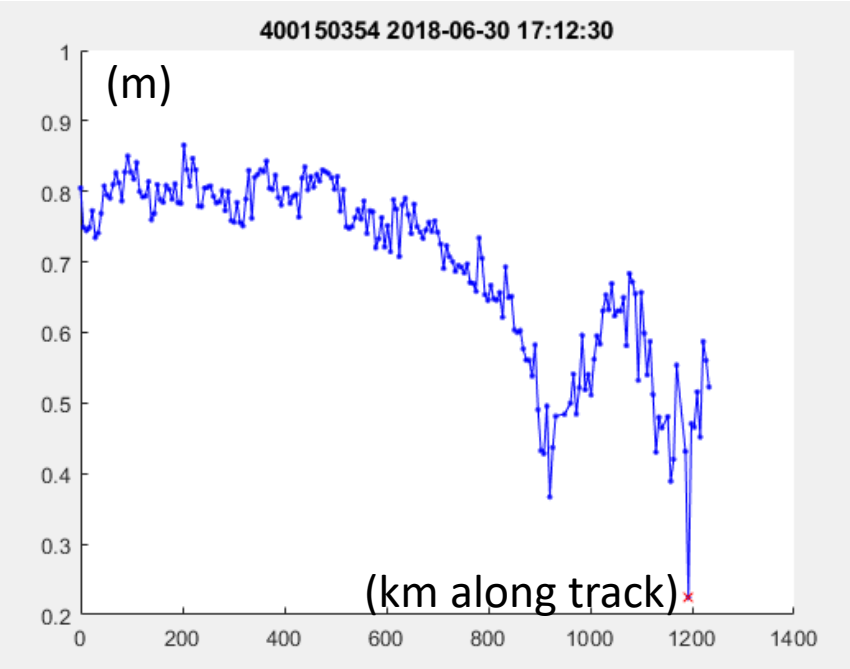


[BELOW] Sea surface height (SSH) observations in a 3-day window (from Jason-3, Altika, CryoSat, Sentinel-3/3b)



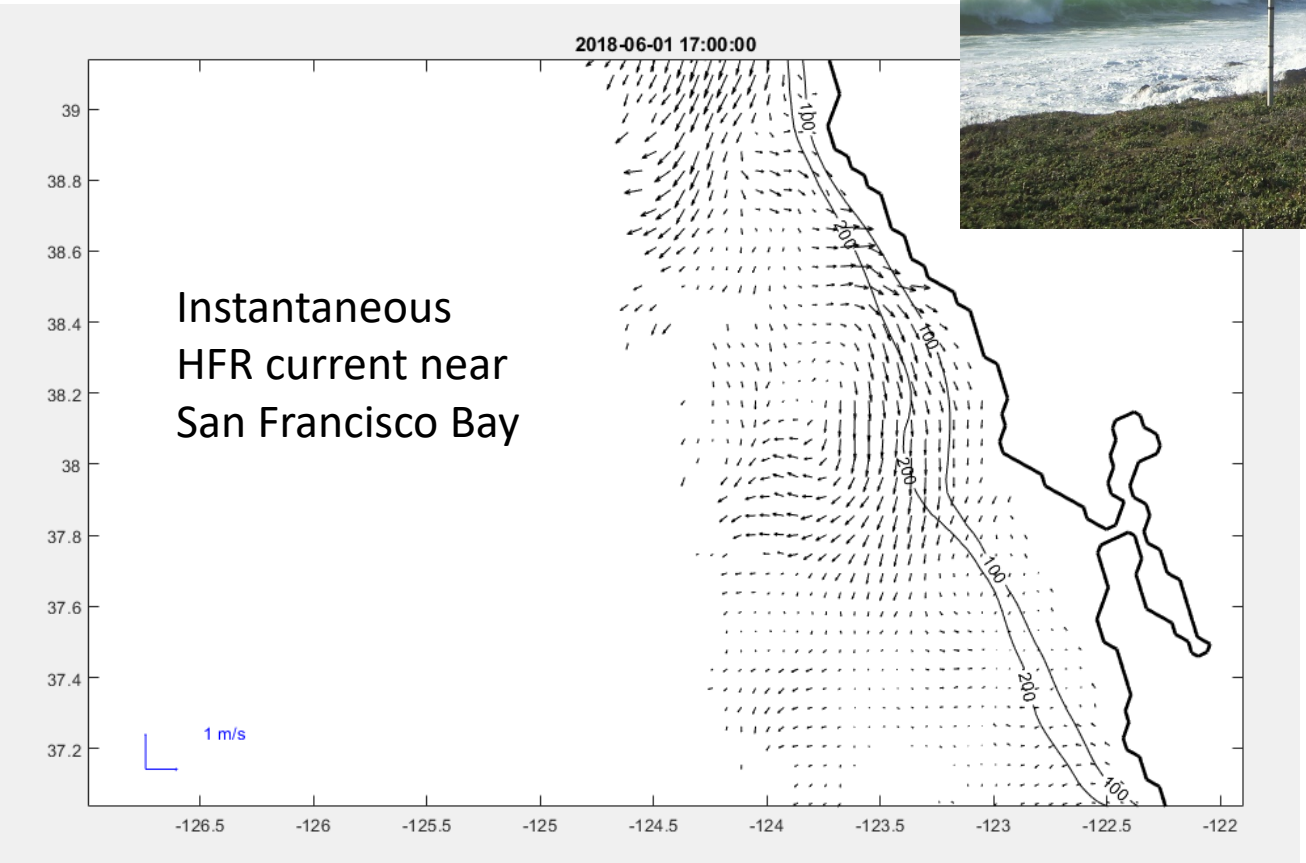
[RIGHT]: The sea-surface slope in the altimetry data is associated with large geostrophic currents (eddies, fronts)



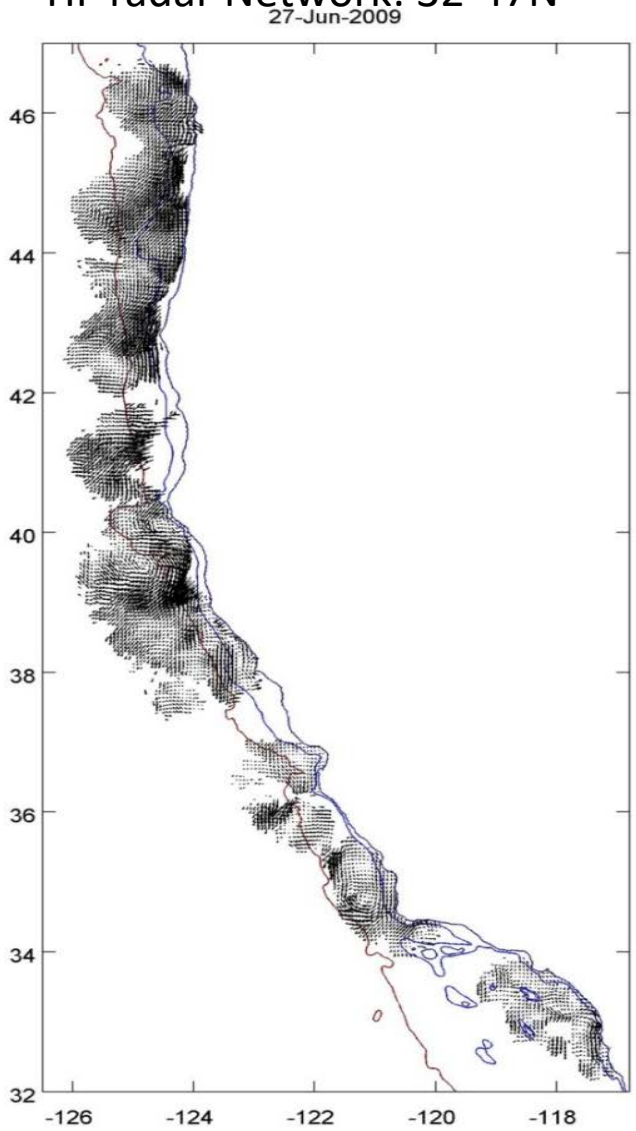


Assimilated data (3): HF radar surface currents

- mapped uv (6km res),
- hourly



US West Coast
HF radar Network: 32-47N

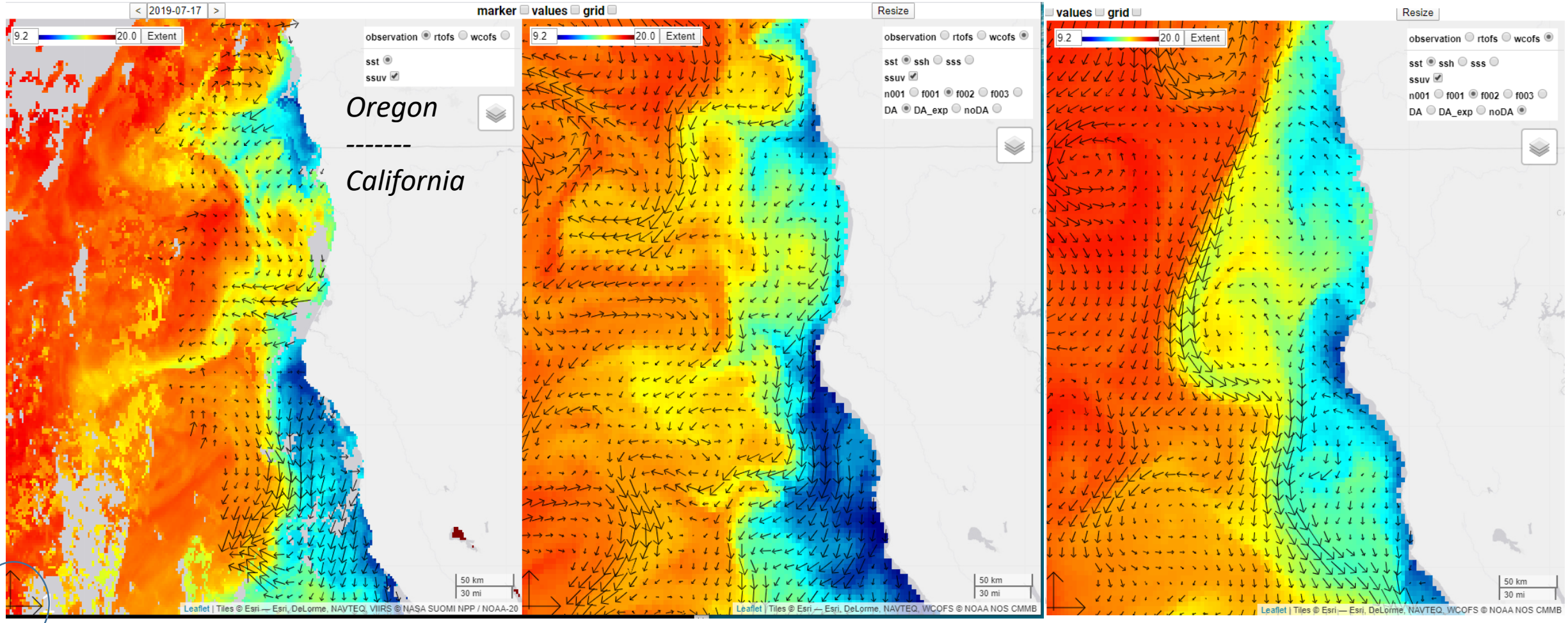


DA improves surface temperature and currents forecasts

Obs: VIIRS SST and HFR

DA

No DA



Surface current scale: 1 m/s

Synergy with UFS:

- Test utility of FV3 GFS atmospheric fields with WCOFS (replacing NAM): impact on the accuracy of coastal surface currents and heat content
- Tests utility of UFS oceanic boundary conditions for WCOFS. As planned [H. Tolman's talk], G-RTOFS will be replaced by the UFS coupled ocean-atmosphere coupled forecast system in FY24
- Comparative tests of ROMS and MOM6 in shelf areas
- JEDI enabled 4DVAR: (ROMS TL and ADJ will be made JEDI-compliant; potential advantages include improved background error covariances and data functionals for altimetry and HF radar data)

More generally, I concur with Andre Van der Westhuysen's comments (plenary talk on Mon):

6. Further coordination needed across NOAA to finalize Coastal Application Team representation and scope, i.e. Inundation (2D) and Coastal Processes (3D).
7. Recognition of additional coastal models within UFS modeling framework to support NOAA mission needs.
8. Development of a 3D ocean modeling strategy that describes how NOAA will support the temporal and spatial scales required to effectively fulfill NOAA's diverse missions in a changing climate.
9. Integrate existing and emerging data assimilation capabilities into Marine JEDI.