Data assimilation of satellite observations in OceanMAPS (and future coastal operational systems)

Australian Government
Bureau of Meteorology

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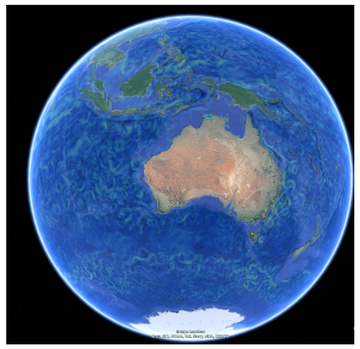
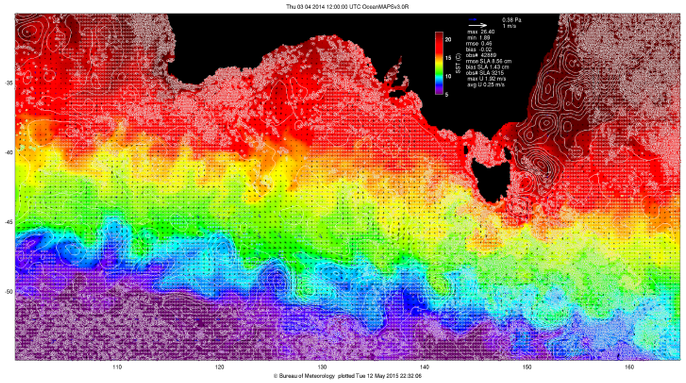
OceanMAPS3

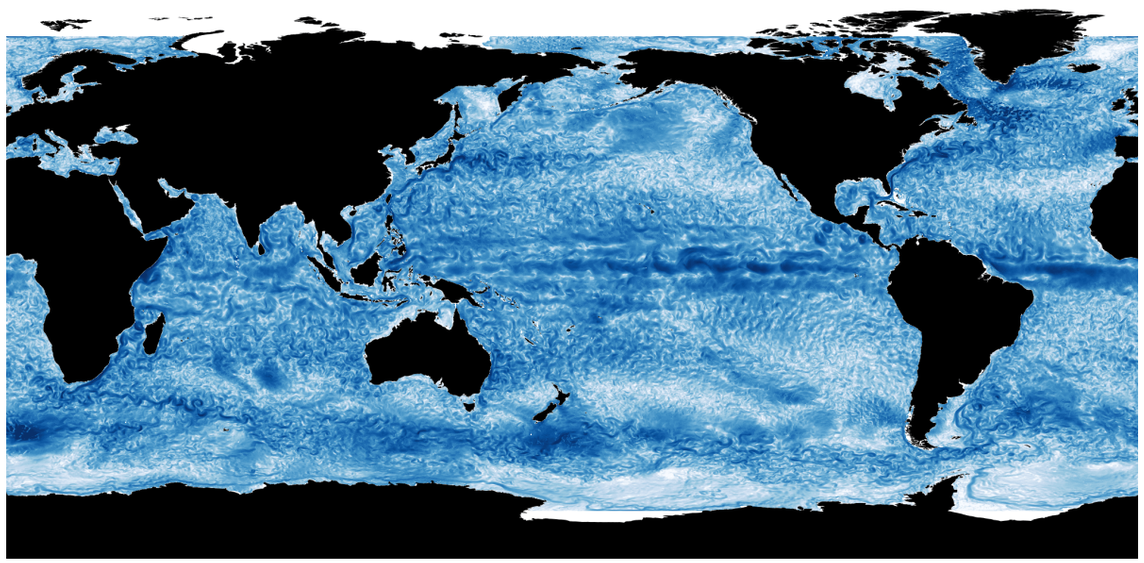
- **Global 0.1° eddy resolving data assimilating ocean prediction system forced by ACCESS-G**





Both SSH and SST are critical for mesoscale eddy resolving ocean forecasting

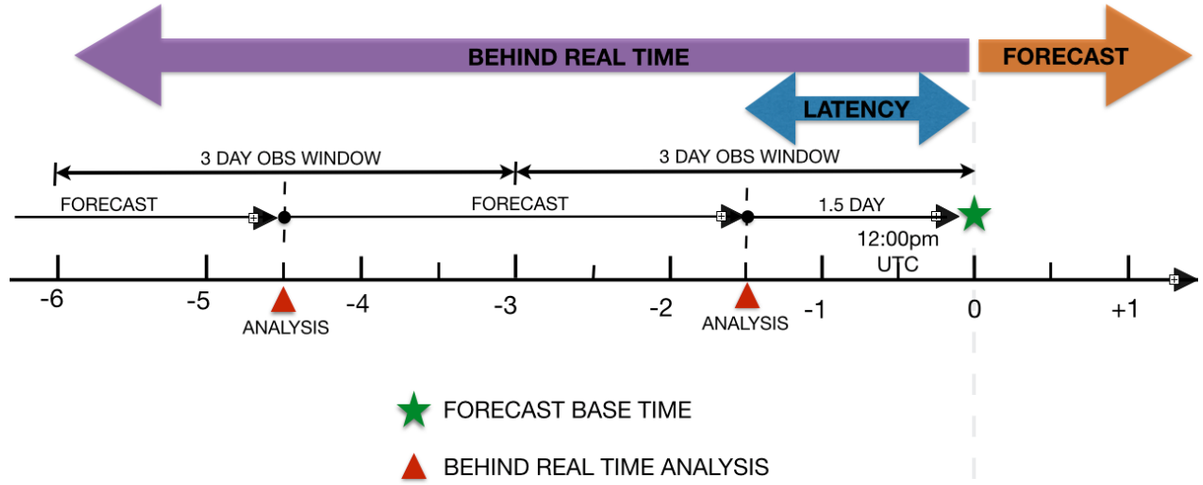
- without altimetry there is no chance of constraining the circulation or initialising the ocean model to a realistic representation of the ocean state.
- errors become larger than errors from climatology
- ocean eddies will be in wrong places and system will have virtually no forecast skill

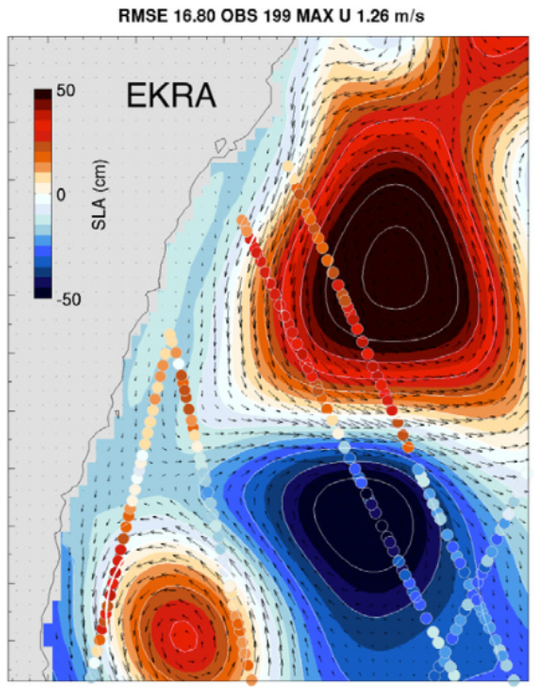


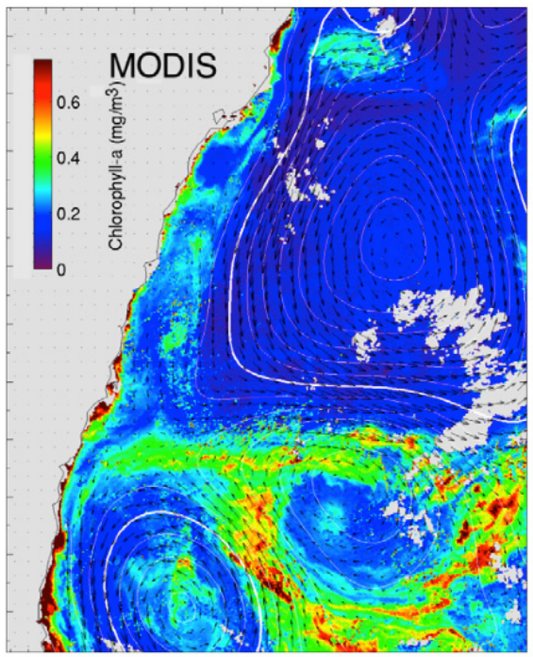
Satellite Observations (near-real time)

All observations assimilated and used for validation

- SST
  - AVHRR (NAVO)
  - WindSAT
  - AMSR2
- RADS
  - ENVISAT
  - JASON
  - CRYOSAT
  - SARAL







EnKF-C

- Generic interface of model to observations
- Can be used in lightweight mode to calculate innovation statistics using either raw or super-observations
- Super-observations made by weighting all observations within grid cell by their inverse error variance
- Easy to add new observations
- Diagnostics by customisable region, instrument or platform

```
printing observation statistics:
  region obs.type   # obs.  |for.inn.| |an.inn.|   for.inn.
  ------------------------------------------------------------
  Global
         SLA        249063    0.052      0.028     -0.000
           c2        61513    0.053      0.032     -0.003
           j2        97446    0.052      0.028      0.003
           sa        83658    0.052      0.027     -0.001
           N/A        6446    0.048      0.021      0.000
         SST       1807239    0.313      0.148     -0.001
           AVHRR   1343469    0.300      0.131      0.036
           WindSat  259209    0.417      0.265     -0.200
           N/A      204561    0.268      0.112      0.007
         TEM         57814    0.522      0.324     -0.077
           WMO0056   46440    0.497      0.308     -0.047
           WMO0048     994    0.374      0.305     -0.285
           WMO0052      47    0.347      0.244      0.224
           WMO0057    4421    0.596      0.482     -0.487
           WMO0050     394    0.592      0.250     -0.296
           WMO0053    5518    0.701      0.337      0.050
           0-50m     10983    0.375      0.253     -0.108
           >500m     12837    0.303      0.247      0.044
         SAL         49466    0.139      0.096     -0.006
           WMO0056   44085    0.129      0.084      0.004
           WMO0048    1065    0.409      0.374     -0.362
           WMO0057    4316    0.173      0.153     -0.014
           0-50m      9193    0.263      0.176     -0.063
           >500m     12323    0.053      0.047     -0.018
  Australia
         SLA         26427    0.048      0.028     -0.011
           c2         8754    0.054      0.033     -0.018
           j2         8315    0.043      0.025     -0.002
           sa         8691    0.049      0.027     -0.013
           N/A         667    0.039      0.020     -0.009
         SST       221928    0.265      0.128     -0.012
           AVHRR   173034    0.262      0.120      0.006
           WindSat  24208    0.325      0.214     -0.146
           N/A      24686    0.230      0.099     -0.004
         TEM         6951    0.482      0.297     -0.025
           WMO0056   6542    0.478      0.294     -0.034
           WMO0057     80    0.314      0.265     -0.082
           WMO0053    329    0.618      0.367      0.149
           0-50m     1212    0.340      0.253     -0.091
           >500m     1828    0.263      0.218      0.075
         SAL         6293    0.106      0.060      0.023
           WMO0056   6213    0.107      0.060      0.022
           WMO0057     80    0.069      0.041      0.056
           0-50m     1092    0.211      0.107     -0.002
           >500m     1720    0.033      0.029     -0.014
  Tasman
         SLA         2701    0.065      0.032     -0.001
           c2         914    0.075      0.038     -0.002
           j2         880    0.058      0.028      0.006
           sa         832    0.062      0.029     -0.009
           N/A         75    0.054      0.025     -0.007
```

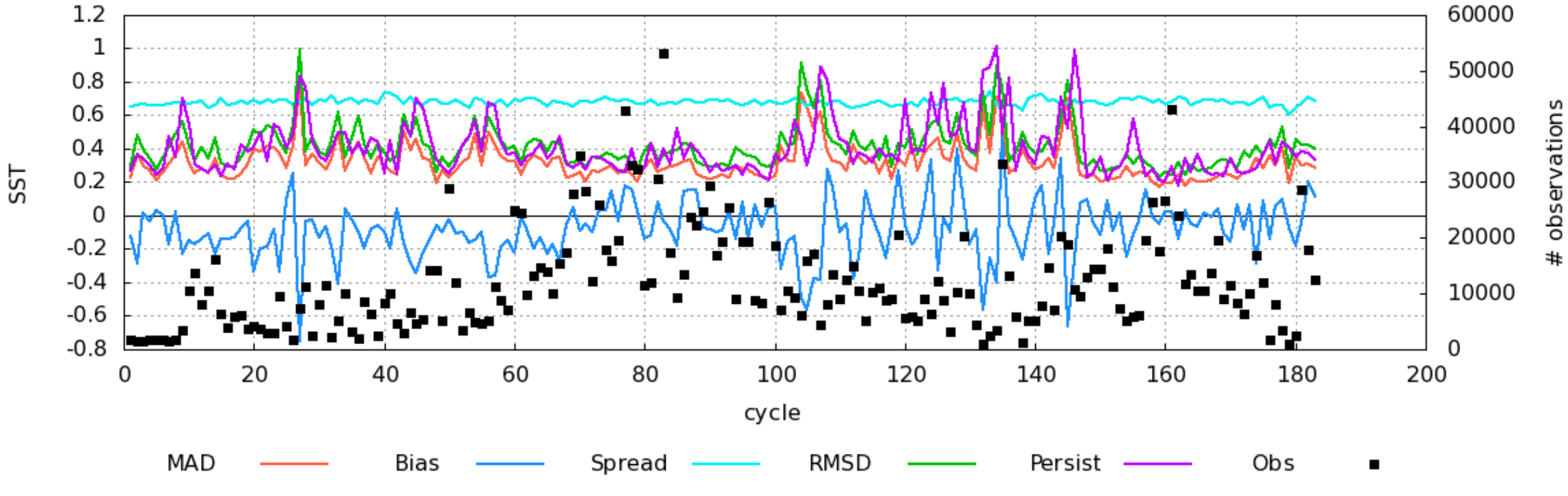
Adaptive QC

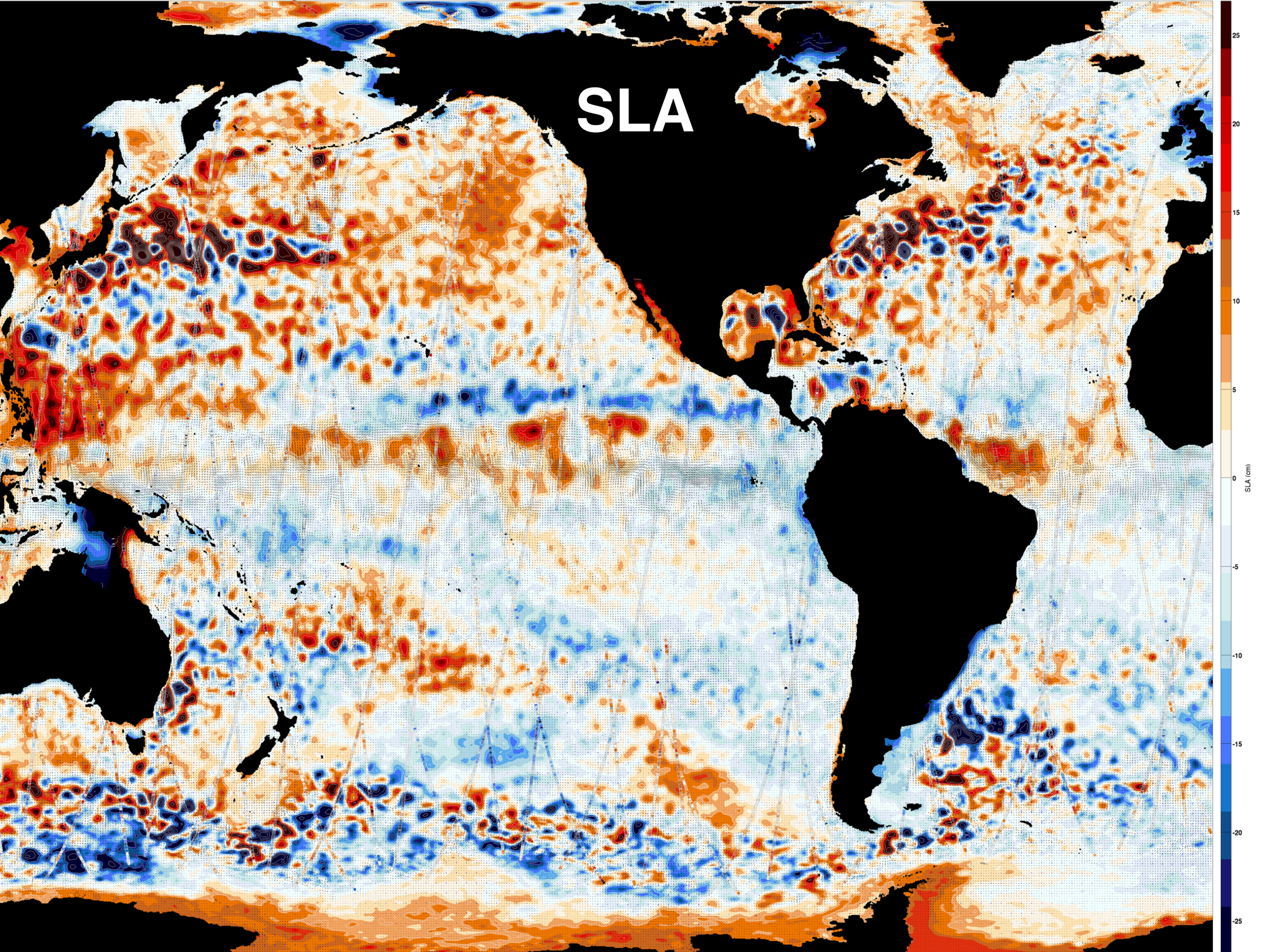
- EnKF-C makes it possible to withhold batches of observations with unreasonably large bias and/or deviations from the model state.

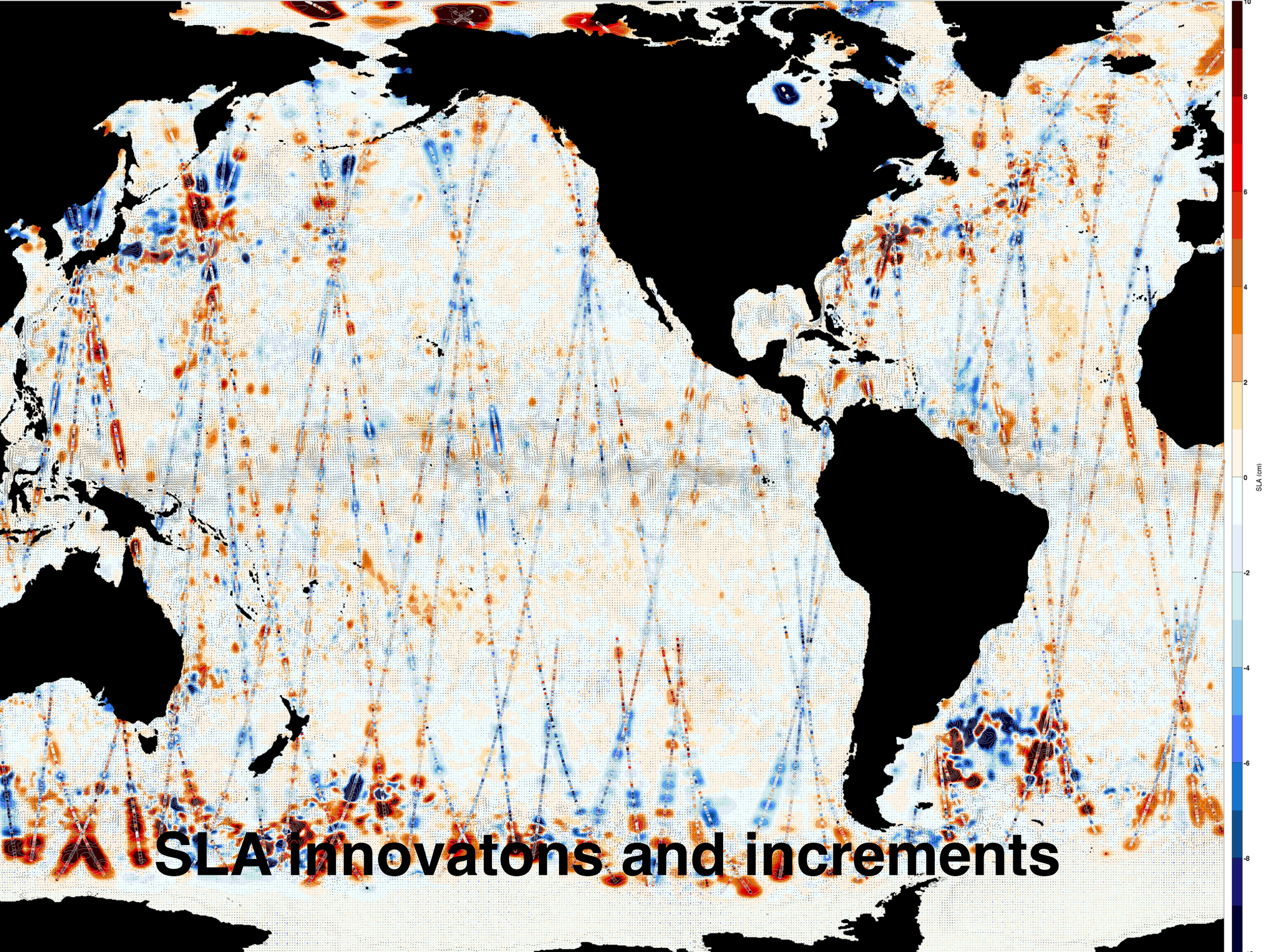
- The user can set the batch sizes and threshholds for bias and mean absolute deviation.

- It also has the ability to assimilate all observations but limit the analysis increment by a factor of ensemble spread.

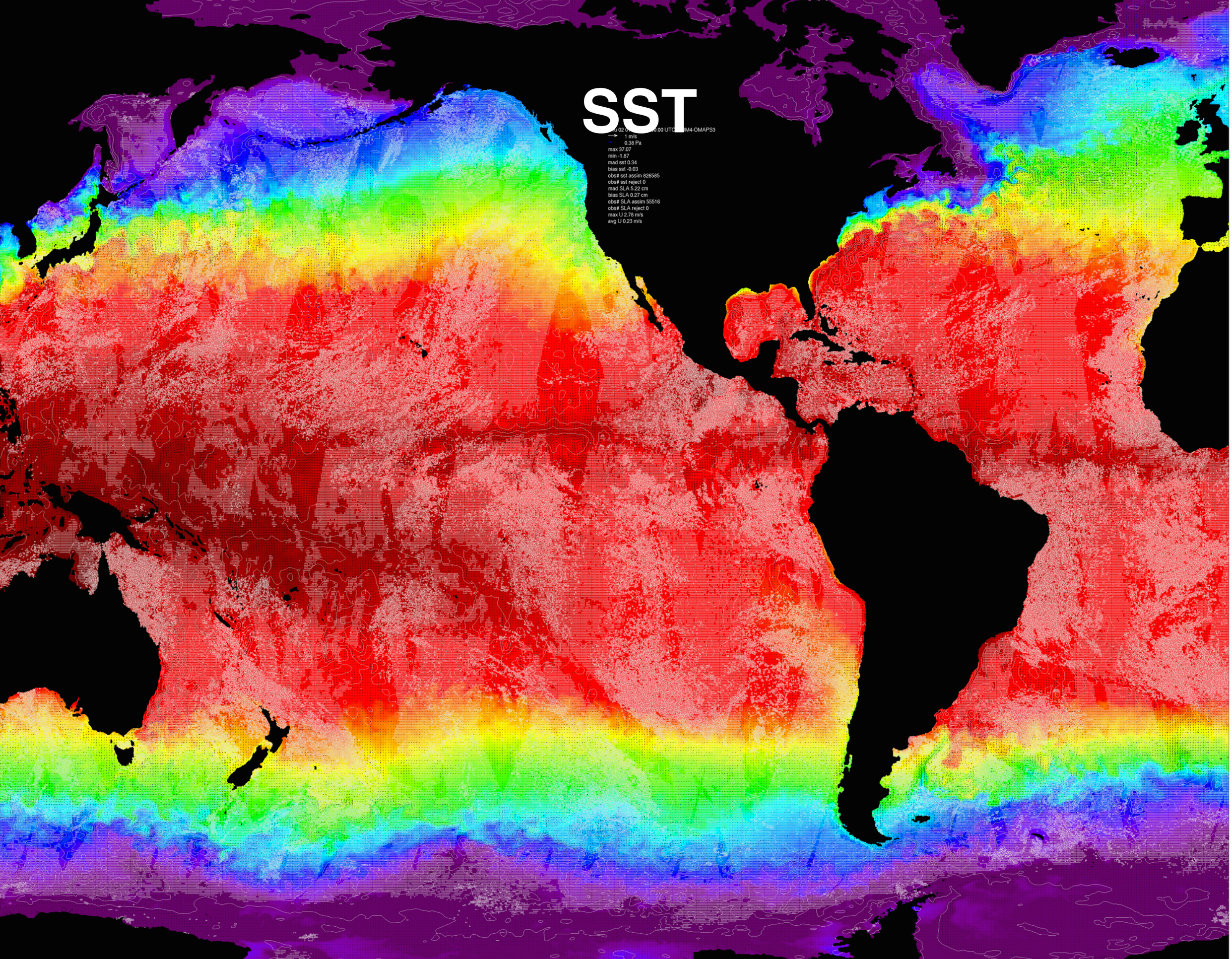
- This means that the errors will show up as spikes in the stats, however, will have minimal impact on the system.




SLA
25
20
15
10
5
0
-5
-10
-15
-20
-25
SLA (cm)


SLA innovatons and increments
SLA (cm)
10
8
6
4
2
0
-2
-4
-6
-8

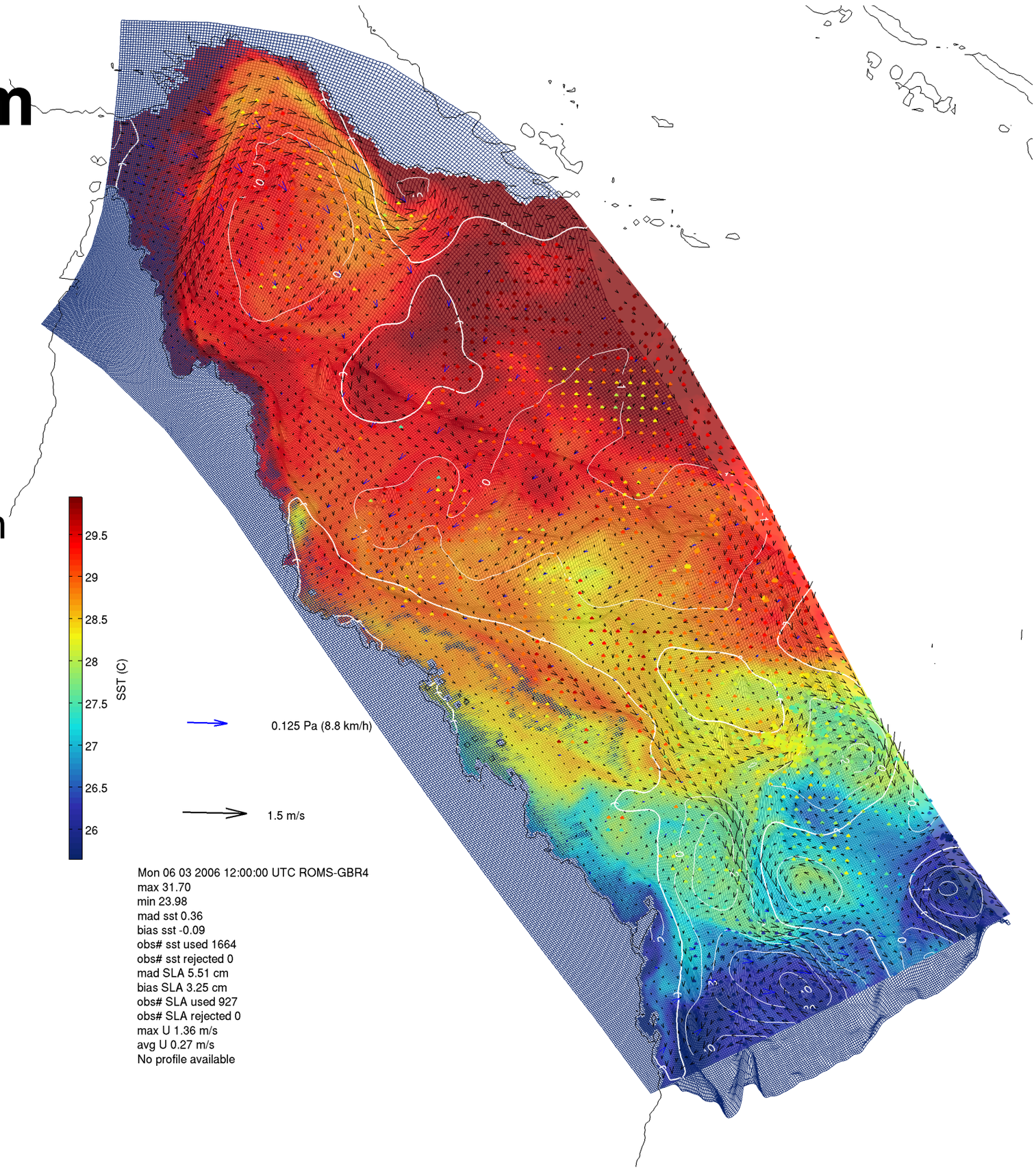
SST


1 m/s
0.38 Pa
max 37.07
min -1.87
mad sst 0.34
bias sst -0.03
obs# sst assim 826585
obs# sst reject 0
mad SLA 5.22 cm
bias SLA 0.27 cm
obs# SLA assim 55516
obs# SLA reject 0
max U 2.78 m/s
avg U 0.23 m/s
SST (C)
30
25
20
15
10
5

eReefs regional forecasting system

- **4 km resolution data assimilating ROMS with realistic tide and mesoscale eddy resolving forced by CFSR (historical) and ACCESS (real-time)**

- **Current Satellite Observations** (for assimilation and validation from 2006-present)
  - SST
    - AMSRE
    - AMSR2
    - AVHRR (NAVO)
    - WindSat
    - Pathfinder
  - Altimeters
    - JASON
    - CRYOSAT
    - ENVISAT
    - GEOSAT
    - SARAL



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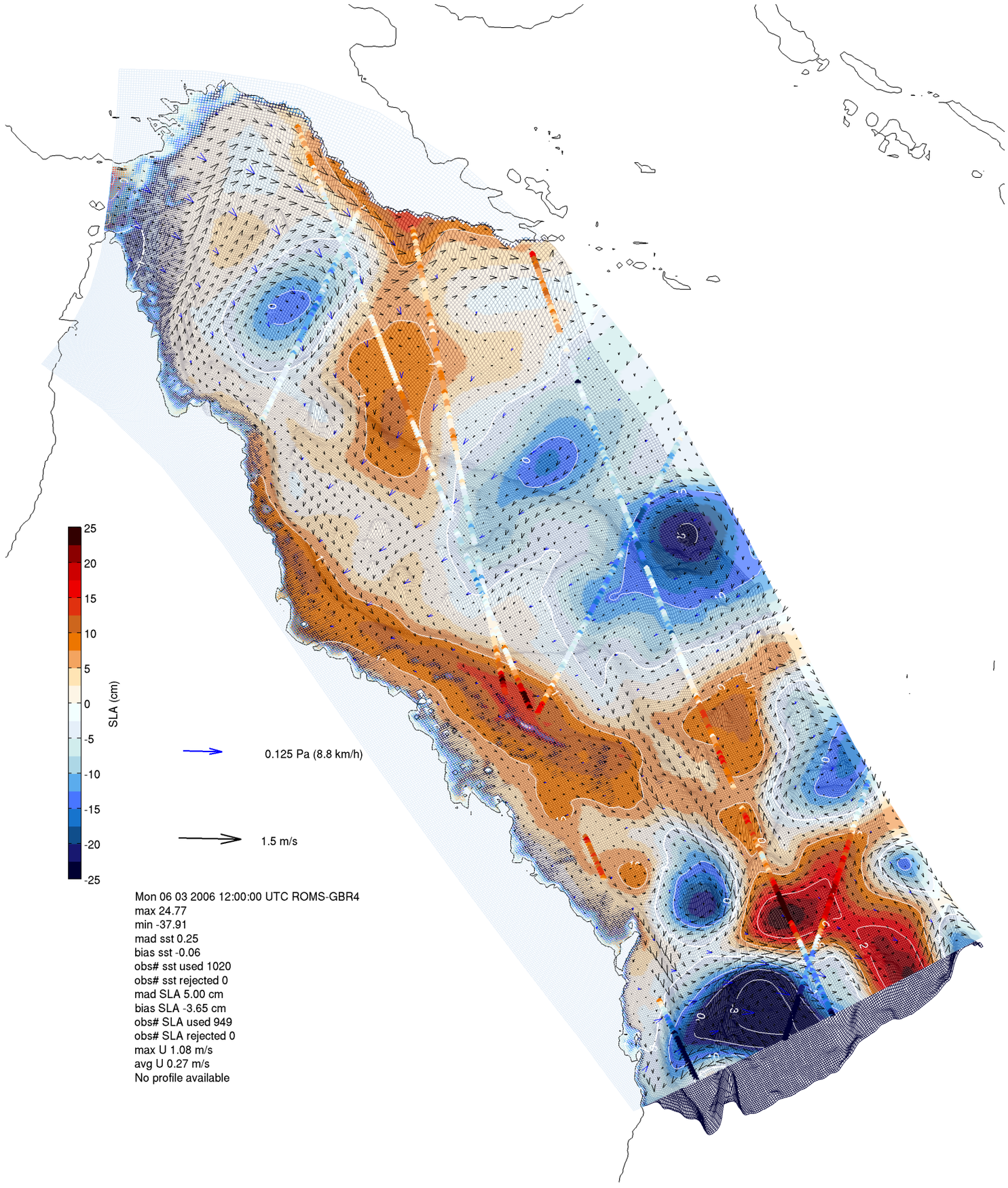
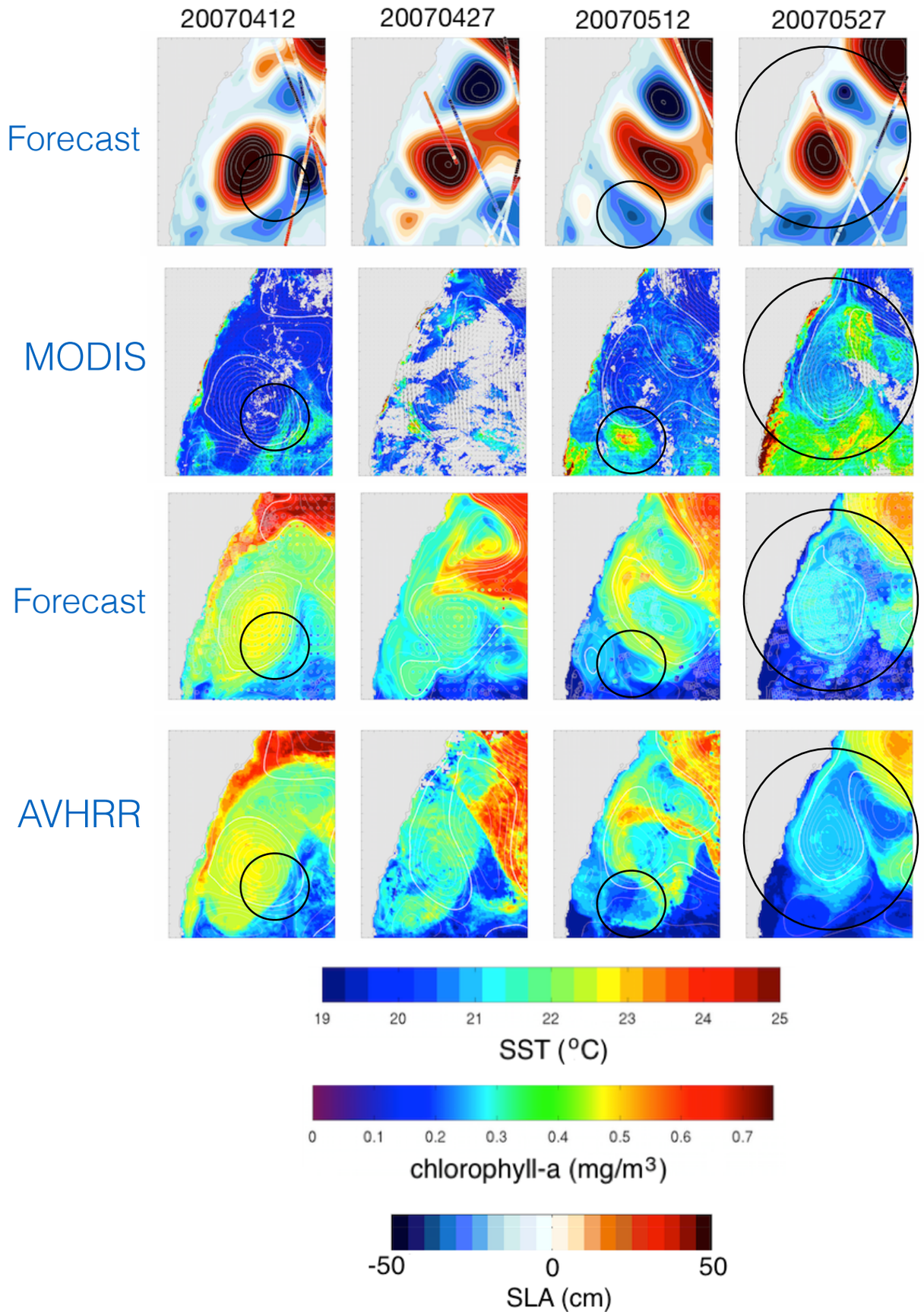


New planned satellite observations for assimilation into Bureau ocean forecasting systems

- **SST**
  - Himarawe-8 (diurnal cycle)
  - VIIRS (replacement)
  - GMI (replacement)
  - Sentinel-3 (IR+MW)
- **SSS (salinity)**
  - SMOS
- **Altimetry**
  - Coastal (RADS)
  - Sea-ice
  - SWOT (2020)
  - Sentinel-3
  - Waves
- **Ocean color validation**
  - Sentinel-3
  - Himarawe-8
- **QSCAT**
  - Ocean surface winds



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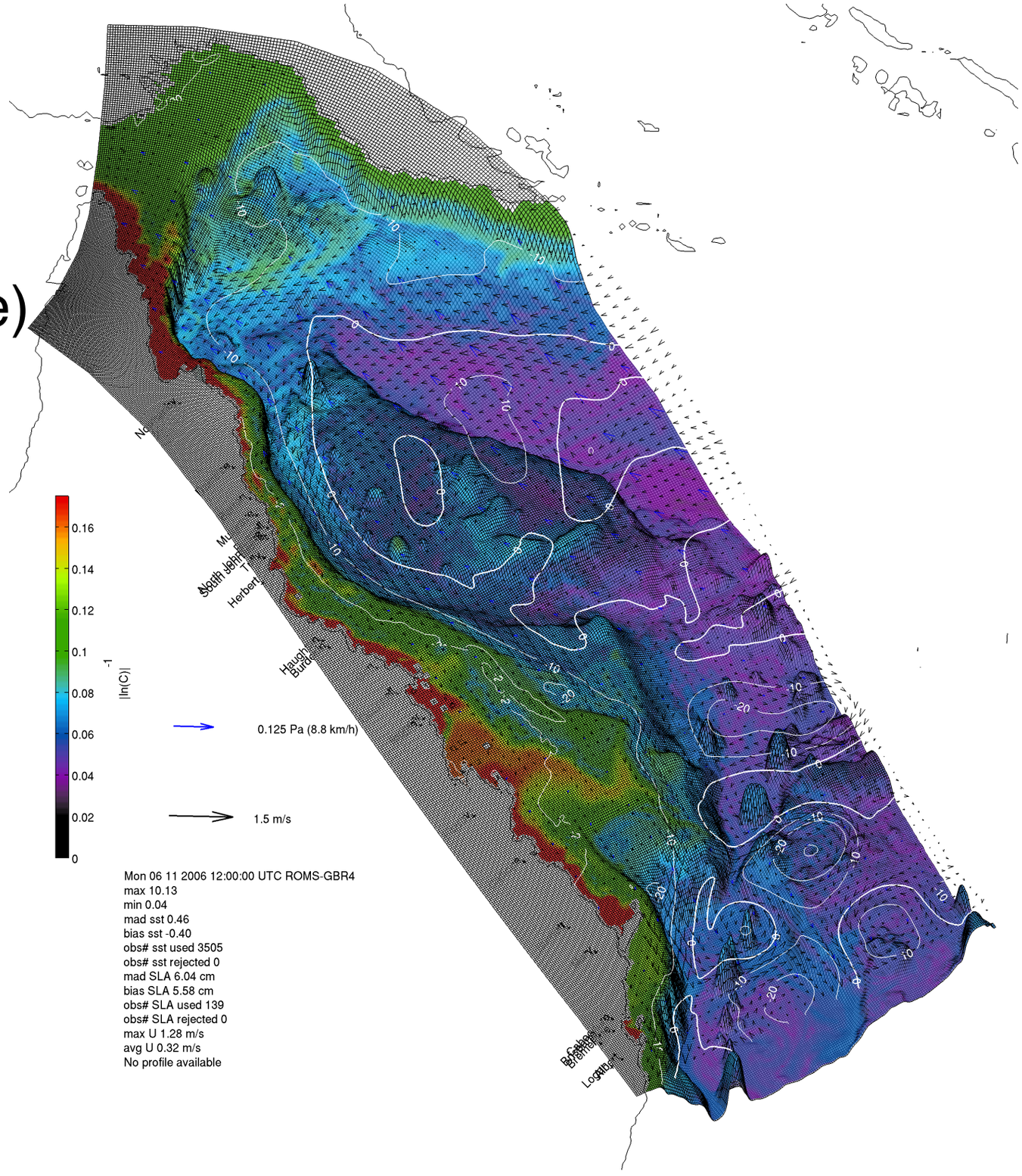

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Uncertainty estimation where possible is key and desirable requirement for all observations

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Thankyou