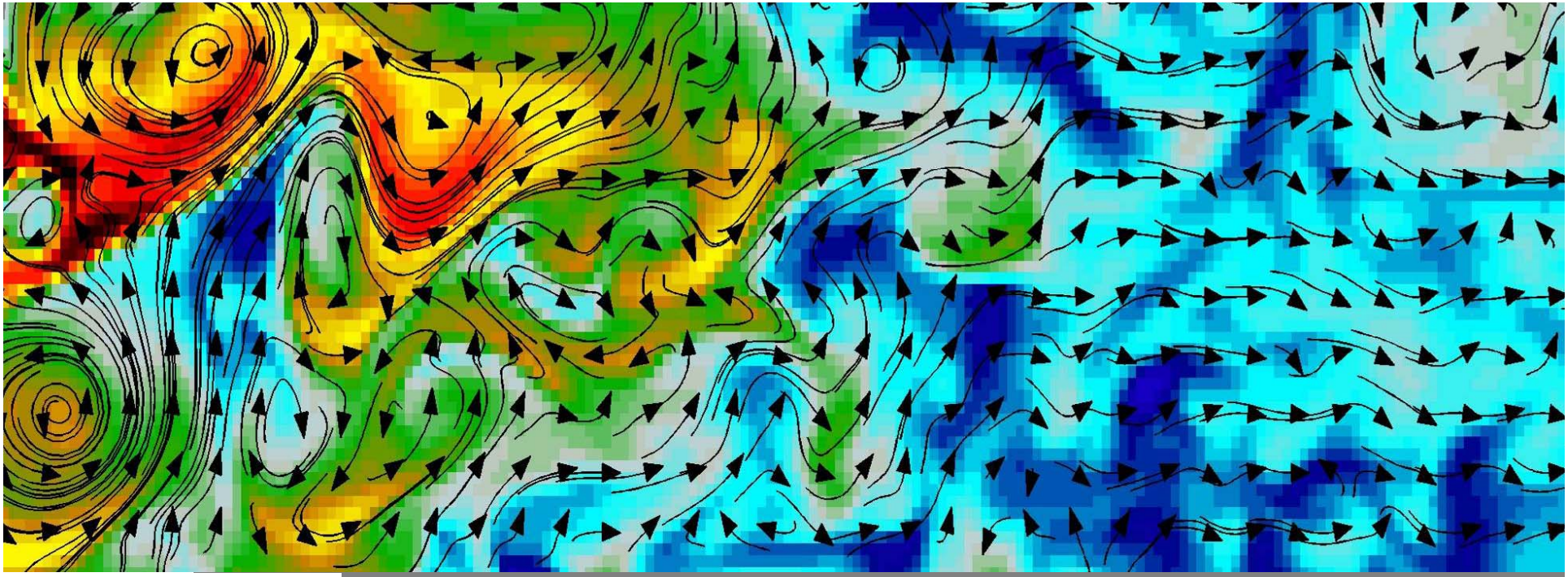


GODAE OceanView

Observing system Evaluation Activities under GODAE OceanView

Peter Oke

CSIRO Marine and Atmospheric Research

Centre for Australian Weather and Climate Research

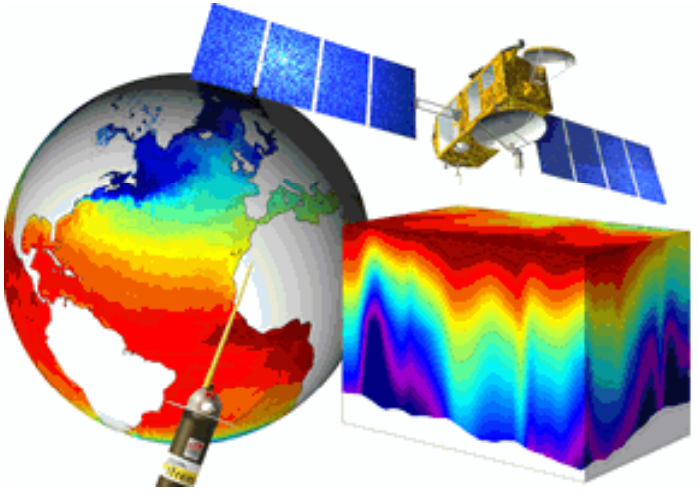
July 2011

"The most exciting phrase to hear in science, the one that heralds the most discoveries, is not 'Eureka!', but 'That's funny…' ", Isaac Asimov (1920-1992)

www.cmar.csiro.au/staff/oke/

Talk Outline

- GODAE and GODAE OceanView
- Observing System Evaluation Task Team (OSEval-TT)
  - Capacity building
  - Research activities
    - Delayed-mode data impacts
    - Observing system design
  - Routine monitoring
    - NRT OSEs
  - Observation Impact Statements
- Summary



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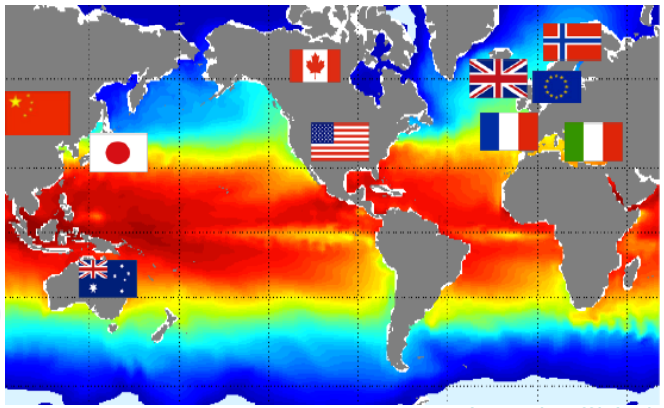
GODAE achievements (1997-2008)

Mission: ***A practical demonstration of the feasibility & utility of high-res, global analyses & short-range forecasts of 3D temperature, salinity and currents ➔ Global operational oceanography***

- **Observing systems and data processing:**
  - Argo (GODAE/CLIVAR pilot project); and
  - GHRSST (GODAE pilot projects)
- **Global modelling & data assimilation capabilities**
  - Short-range forecasting
  - Global and regional reanalysis efforts (Bluelink, GLORYS, TOPAZ)
- **Community activities:**
  - Workshops, symposia, science team meetings
  - Summer schools, text book, special issues
  - Inter-comparison activities

GODAE
GLOBAL OCEAN DATA ASSIMILATION EXPERIMENT



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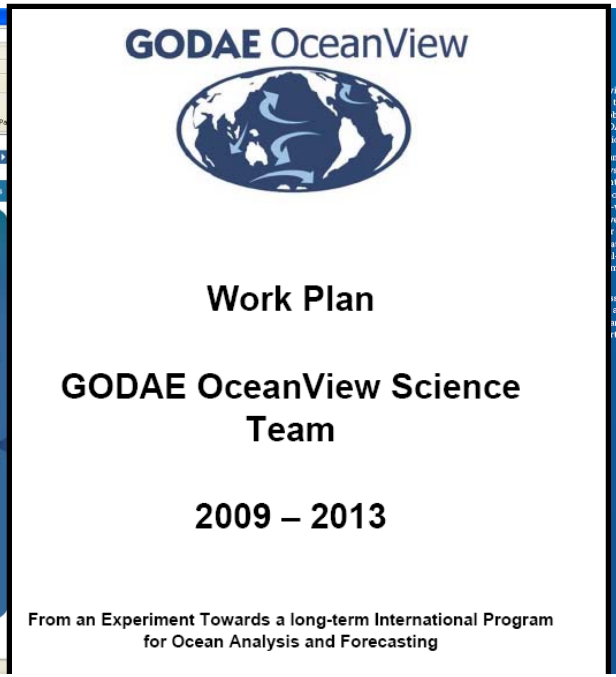
GODAE OceanView (2009-)

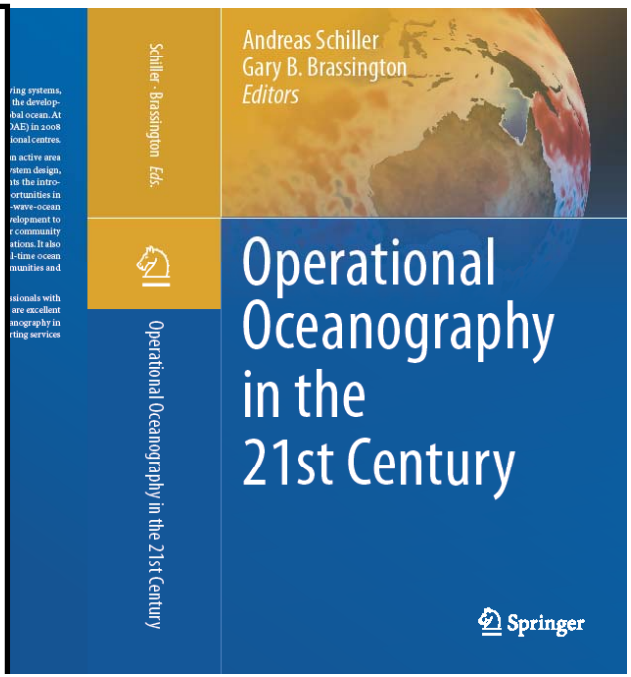
Mission: ***Define, monitor and promote actions aimed at coordinating and integrating research associated with multi-scale and multi-disciplinary ocean analysis and forecasting systems.***

- Five **Task Teams**
  - Coastal Ocean and Shelf Seas
  - Inter-comparison and Validation
  - Marine ecosystem and prediction
  - Observing System Evaluation
  - Short- to medium-range coupled prediction

- **International Patrons** Group (Chaired by E. Lindstrom and M. Bell)
- **Work Plan** (2009-2013)
- New members in 2010 (Brazil, India)
- GODAE OceanView website: https://www.godae-oceanview.org/

GODAE OceanView (2009-)





GOV OSEVal-TT organisation

Co-Chairs:

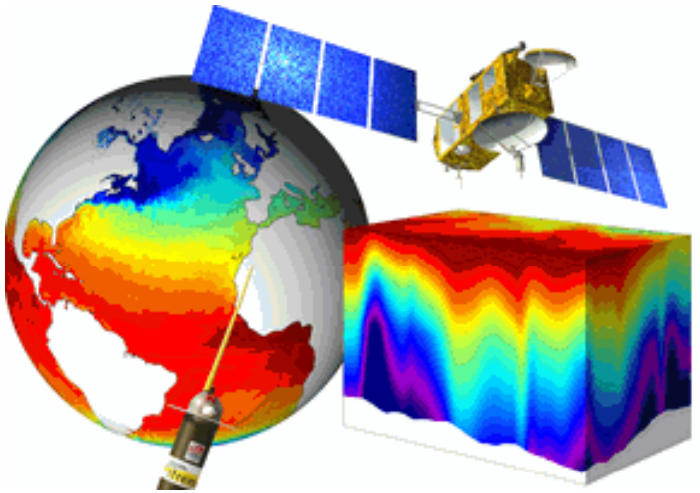
- Peter Oke (CSIRO)
- Gilles Larnicol (CLS)

Core Members:

- Magdalena Balmaseda (ECMWF)
- Laurent Bertino (NERSC)
- Gary Brassington (BoM)
- Jim Cummings (NRL)
- Yosuke Fujii (JMA/MRI)
- Pat Hogan (NRL)

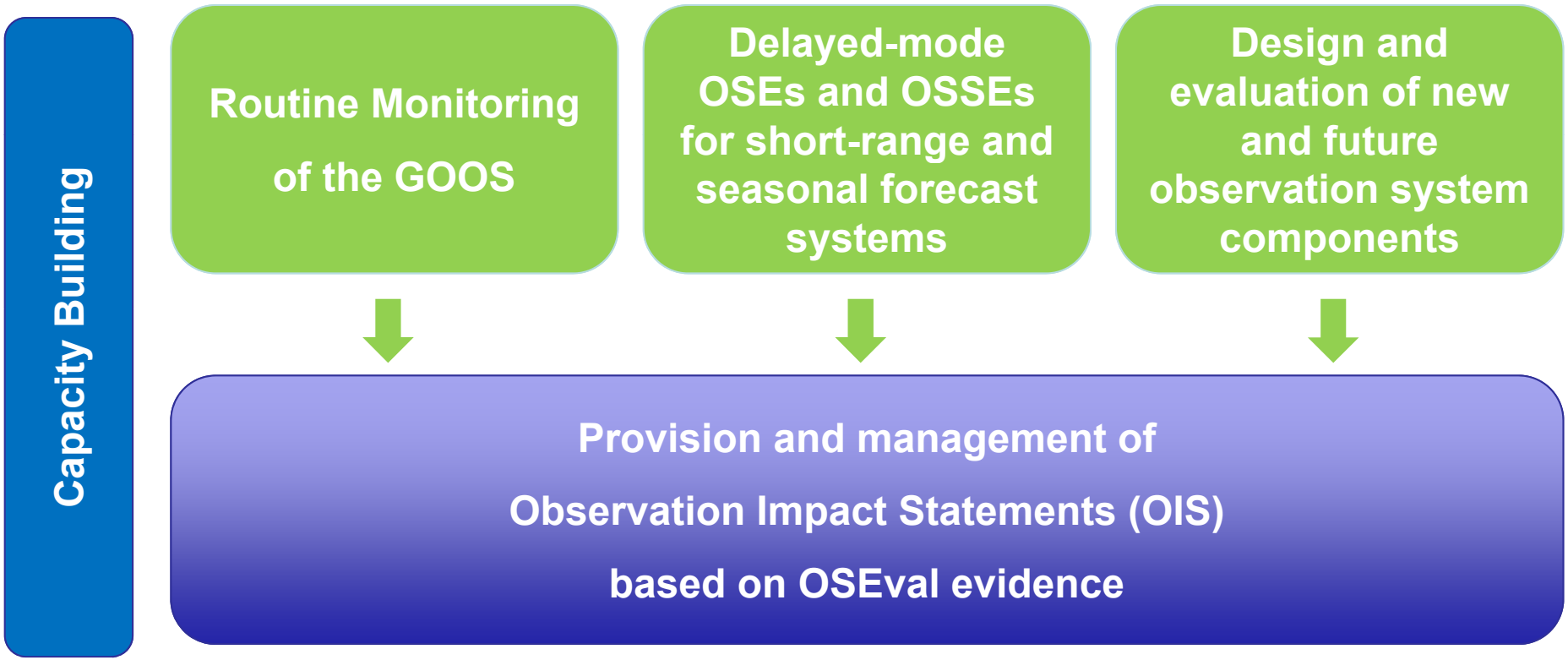
Associate members:

- Mike Bell (UKMet)
- Eric Dombrowsky (Mercator)
- Fabrice Hernandez (Mercator)
- Eric Lindstrom (NASA)
- Andreas Schiller (CSIRO)



www.cmar.csiro.au/staff/oke/

Observing System Evaluation Task Team (OSEval-TT)



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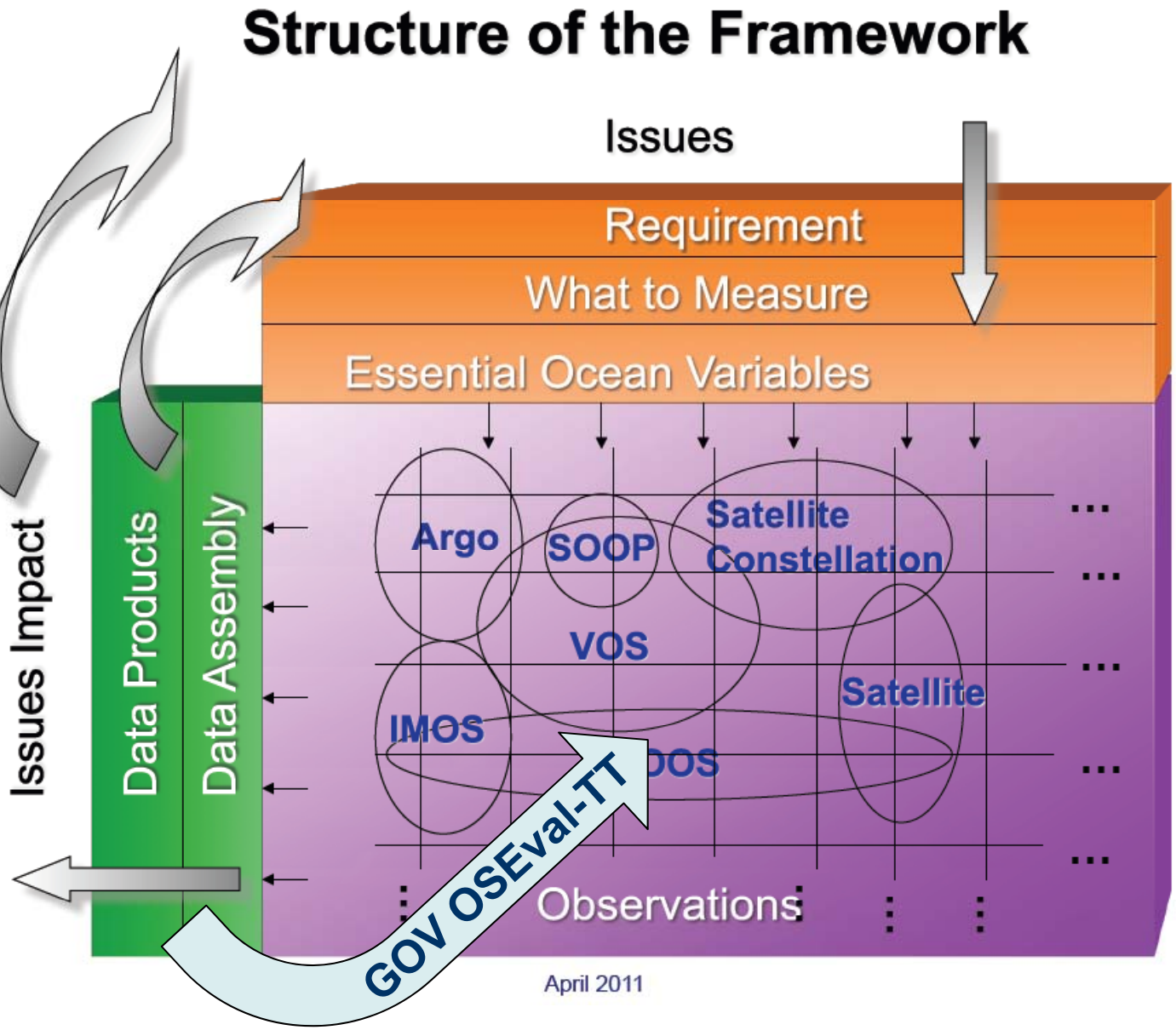
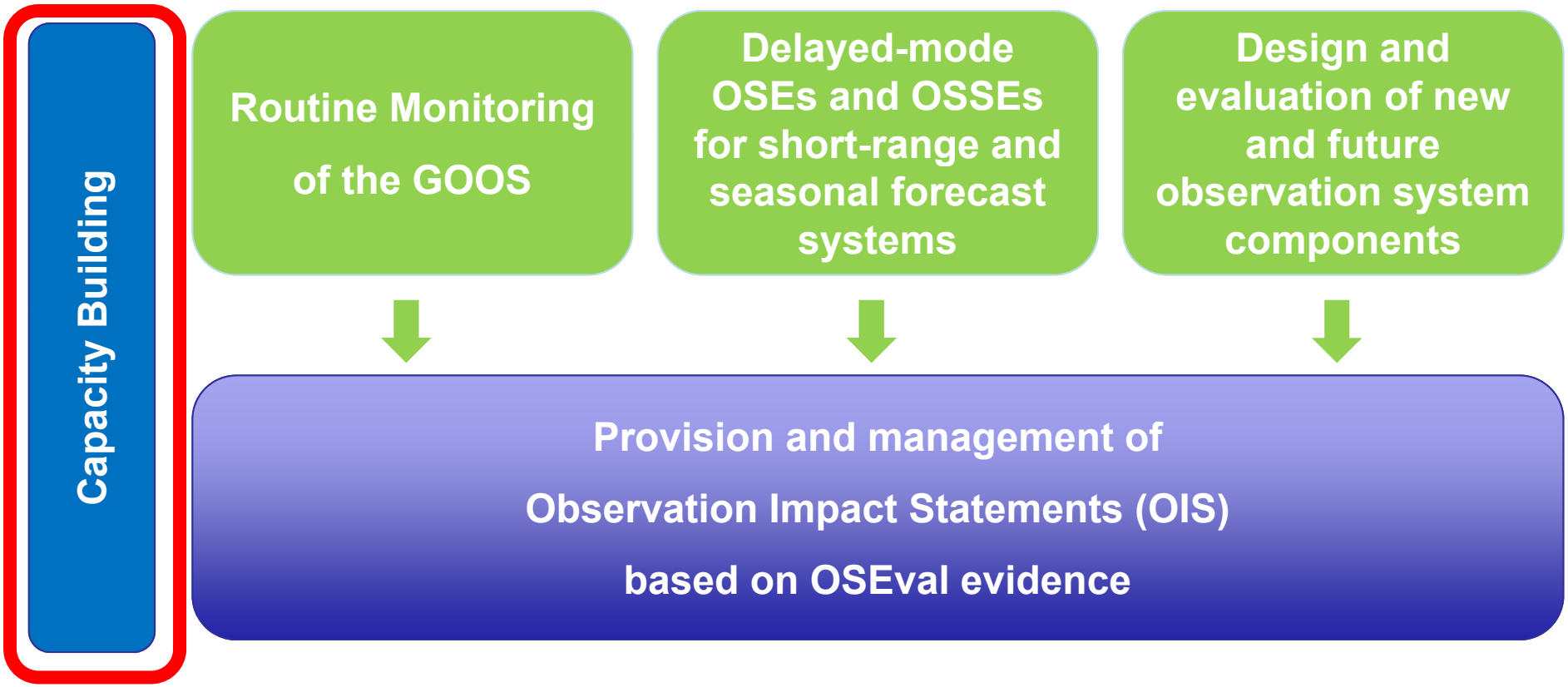
Framework for Ocean Observing: where GODAE OceanView fits



Contributed by E. Lindstrom, OOPC Chair, NASA

www.cmar.csiro.au/staff/oke/

Observing System Evaluation Task Team (OSEval-TT)



www.cmar.csiro.au/staff/oke/

Capability building: GODAE and GOV OSEval Workshops

1st GODAE OSE/OSSE workshop (November 2007, UNESCO, Paris)

- *OSEval-TT established*

2nd GOV OSEVal-TT workshop (June 2009, CLS, Toulouse)

- Initiation of Routine Monitoring activities
- OSEval-TT work plan (draft)

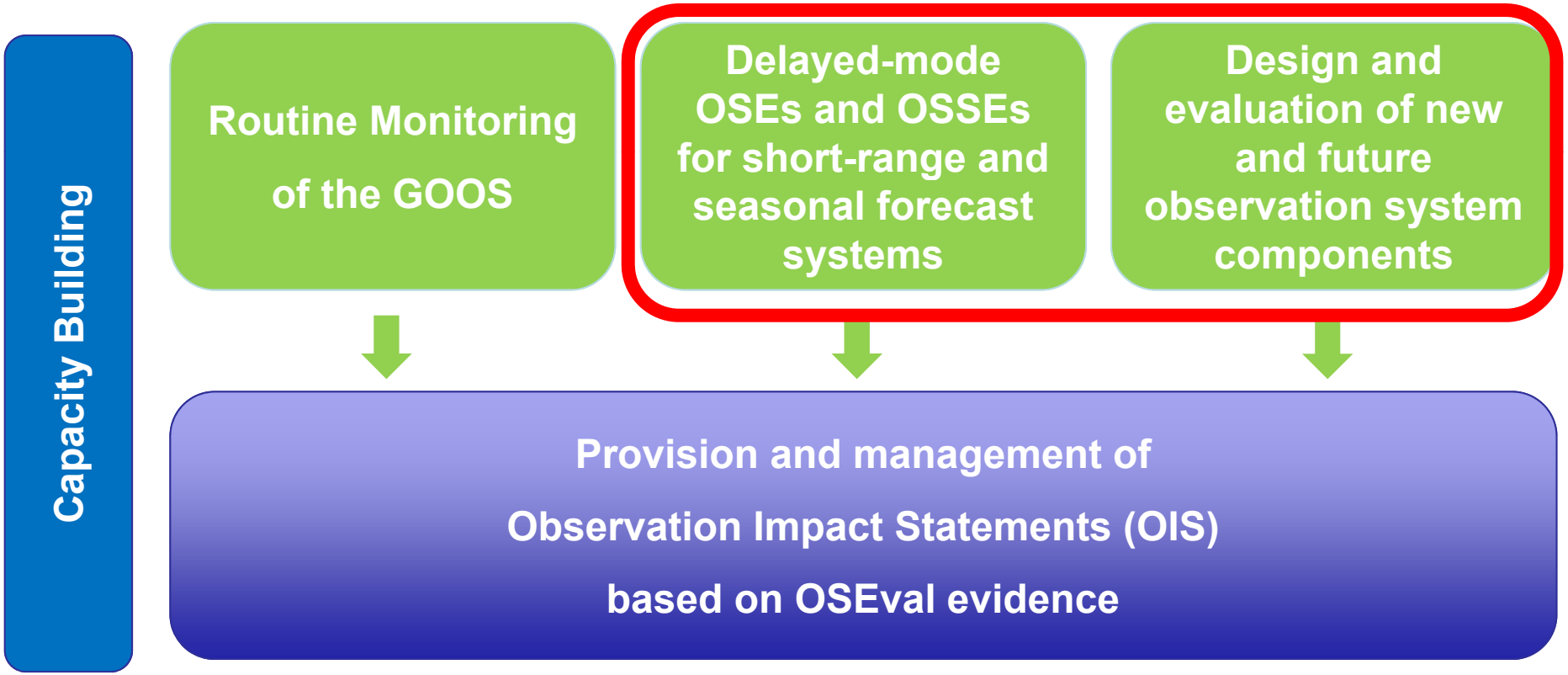
GOVST meeting (November, 2010, JMA, Tokyo)

- Initiation of NRT OSEs (2 groups committed; 1 group delivered)
- OSEval-TT work plan (final; www.godae-oceanview.org)

GODAE OceanView and CLIVAR GSOP workshop on Observing System Evaluation and Inter-comparisons (June 2011, Santa Cruz, CA, USA)

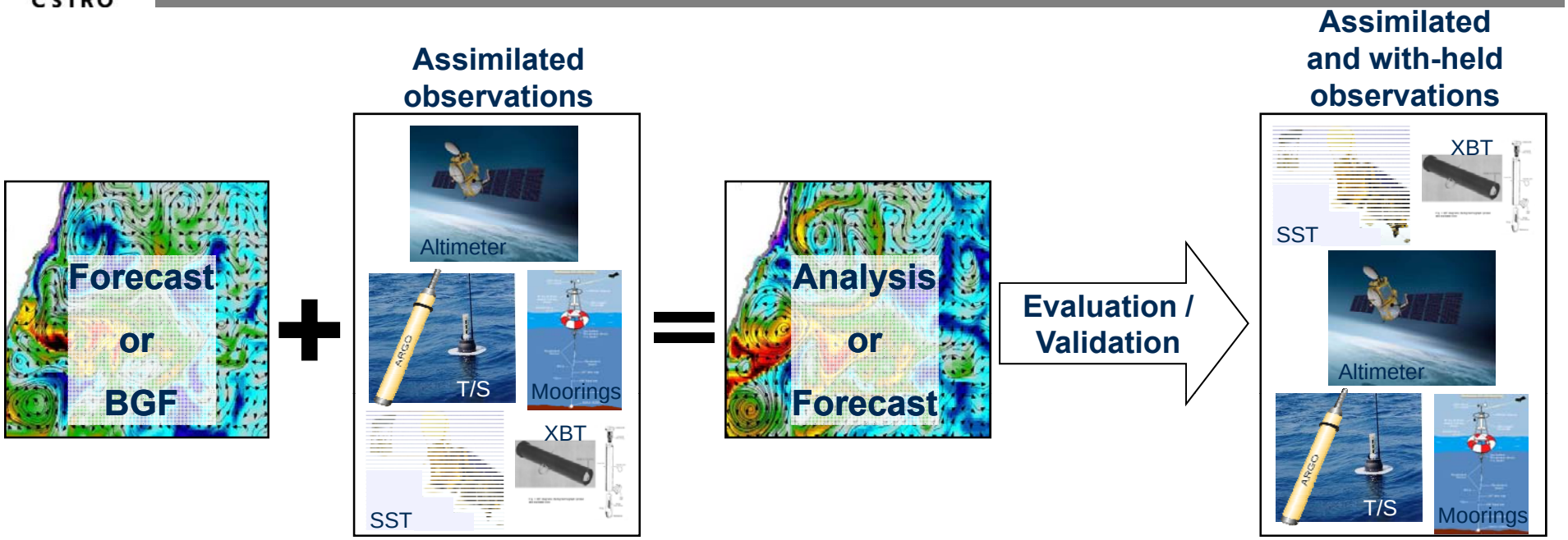
- Extension and expansion of NRT OSEs (4 groups committed; 4 may participate)
- Concept of "Observation Impact Statement" introduced

Observing System Evaluation Task Team (OSEval-TT)



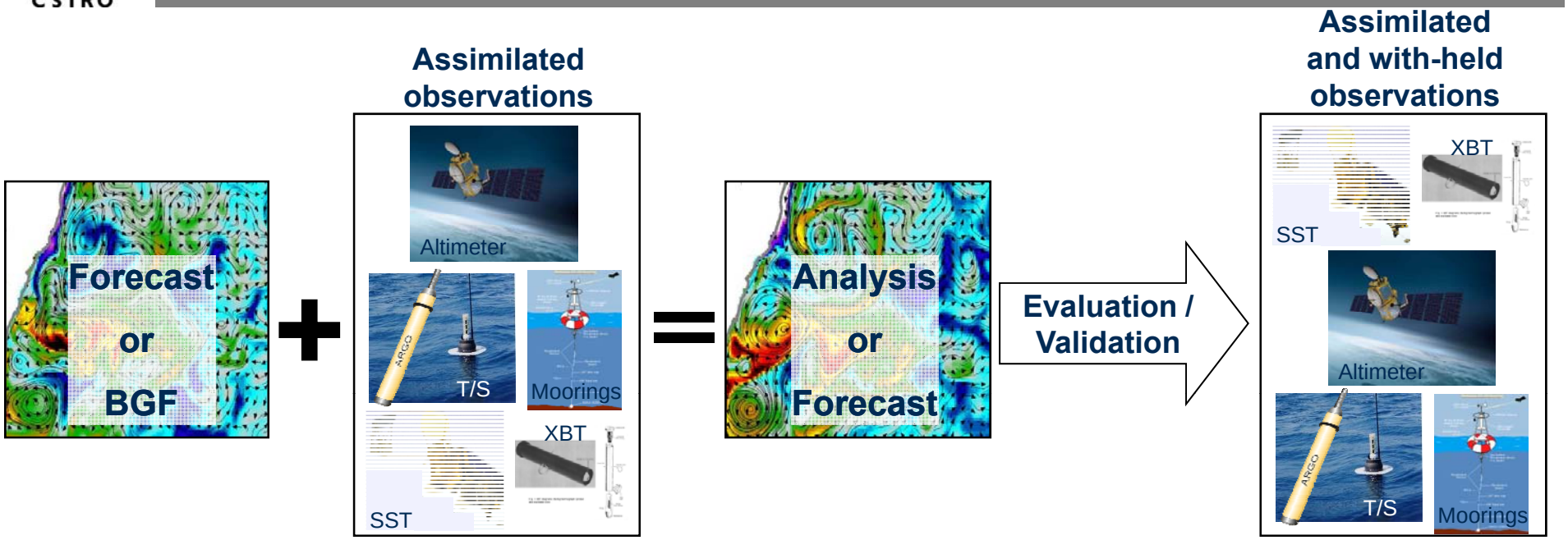
www.cmar.csiro.au/staff/oke/

Introduction: OSEs and OSSEs



www.cmar.csiro.au/staff/oke/

Introduction: OSEs and OSSEs



Observing System Experiments (OSEs)

- Assimilate real observations
- Systematically with-hold observation types

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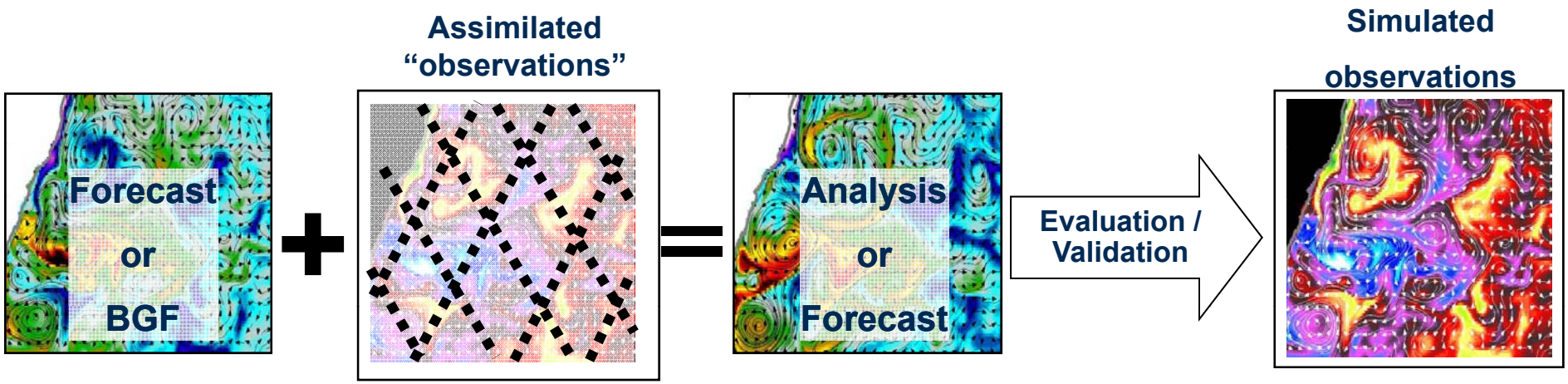
Introduction: OSEs and OSSEs



Observing System Experiments (OSEs)

- Assimilate real observations
- Systematically with-hold observation types

Observing System Simulation Experiments (OSSEs)

- Assimilate pretend "observations" … from a model
- Systematically include different observation types … including future observation types

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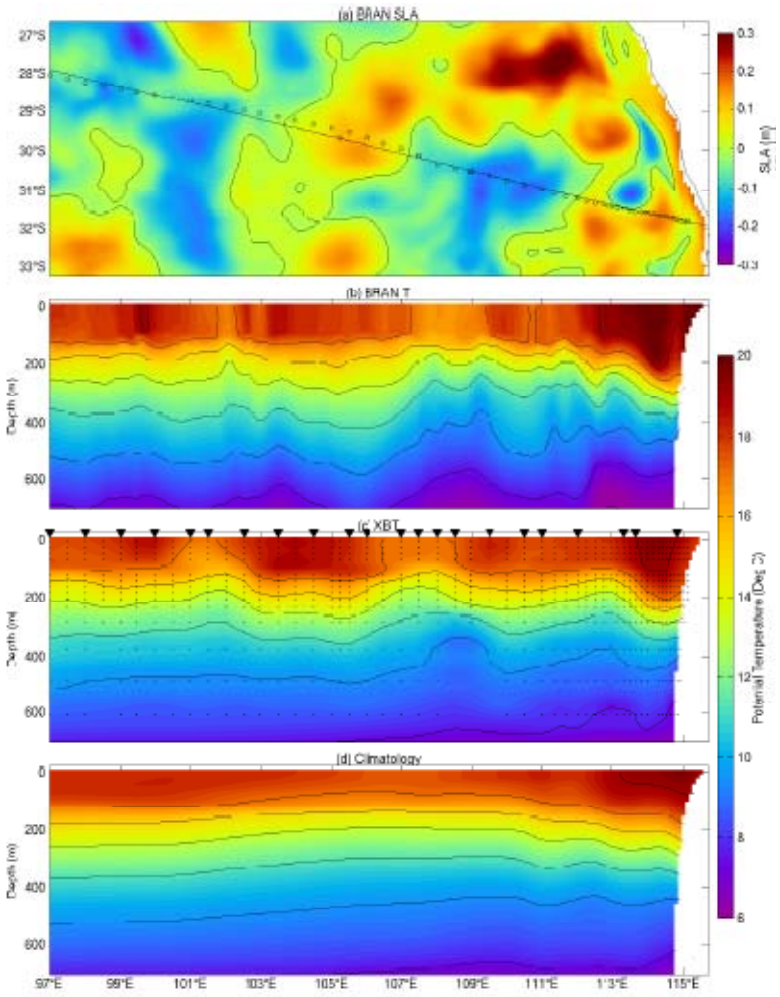
OSEs using the Bluelink system

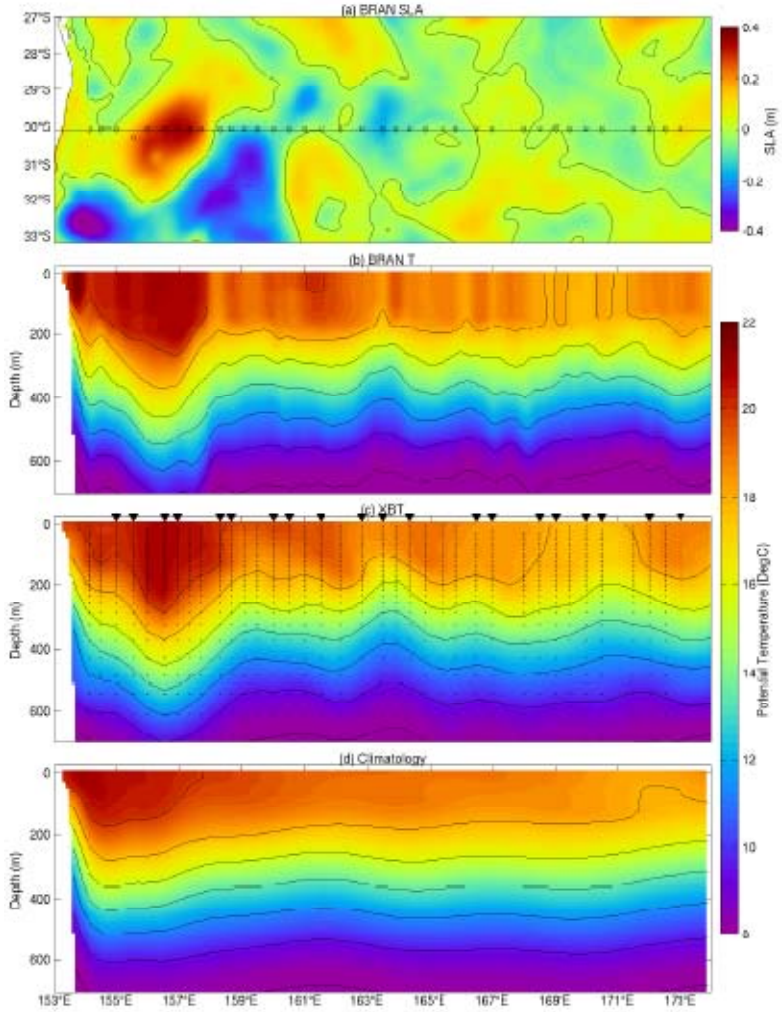
Oke and Schiller

www.cmar.csiro.au/staff/oke/

Evaluation of the Bluelink ReANalysis

Argo floats don't align themselves like XBT …

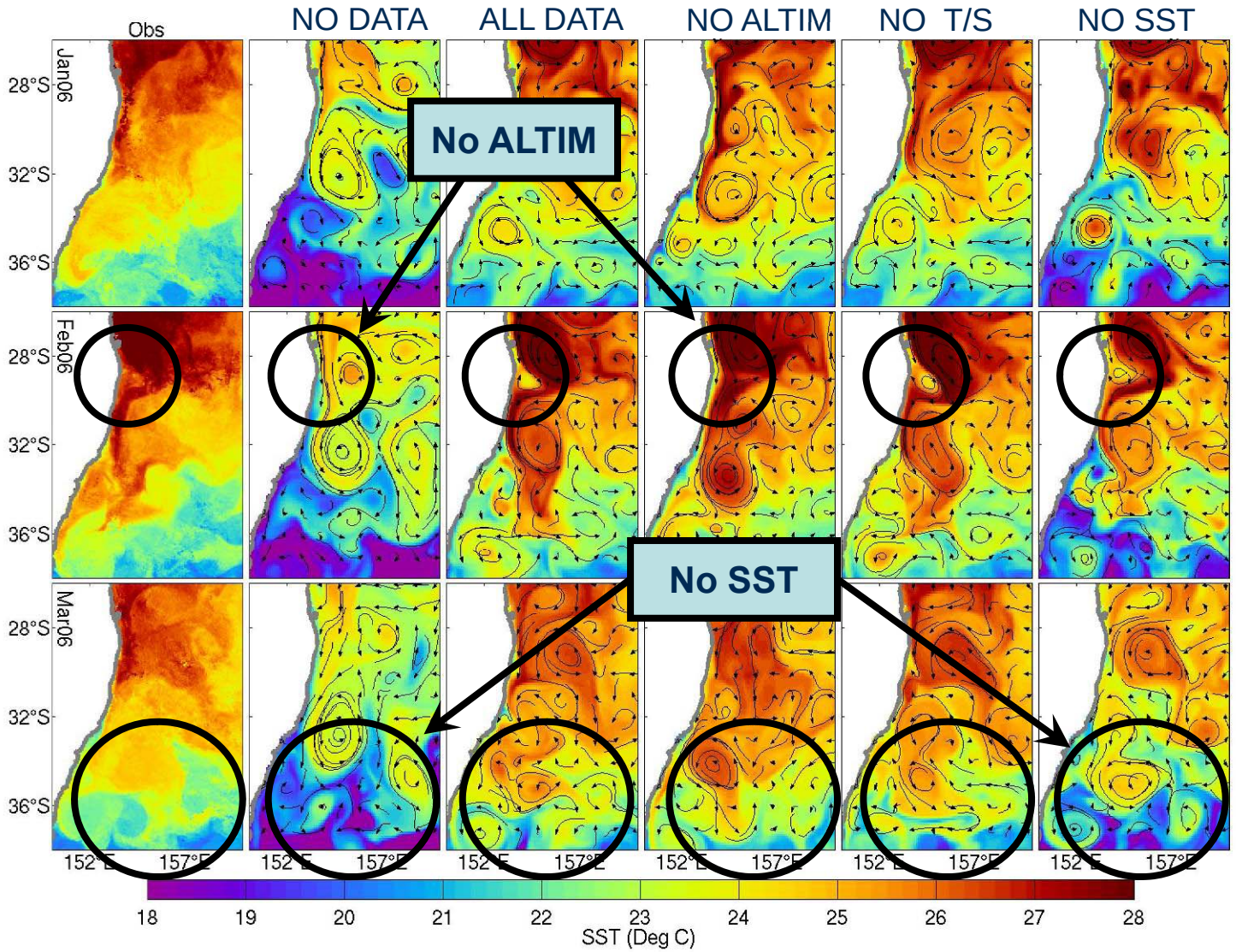




Oke et al. (2008; *Ocean Modelling*)

www.cmar.csiro.au/staff/oke/

Complimentary data types: mesoscale prediction



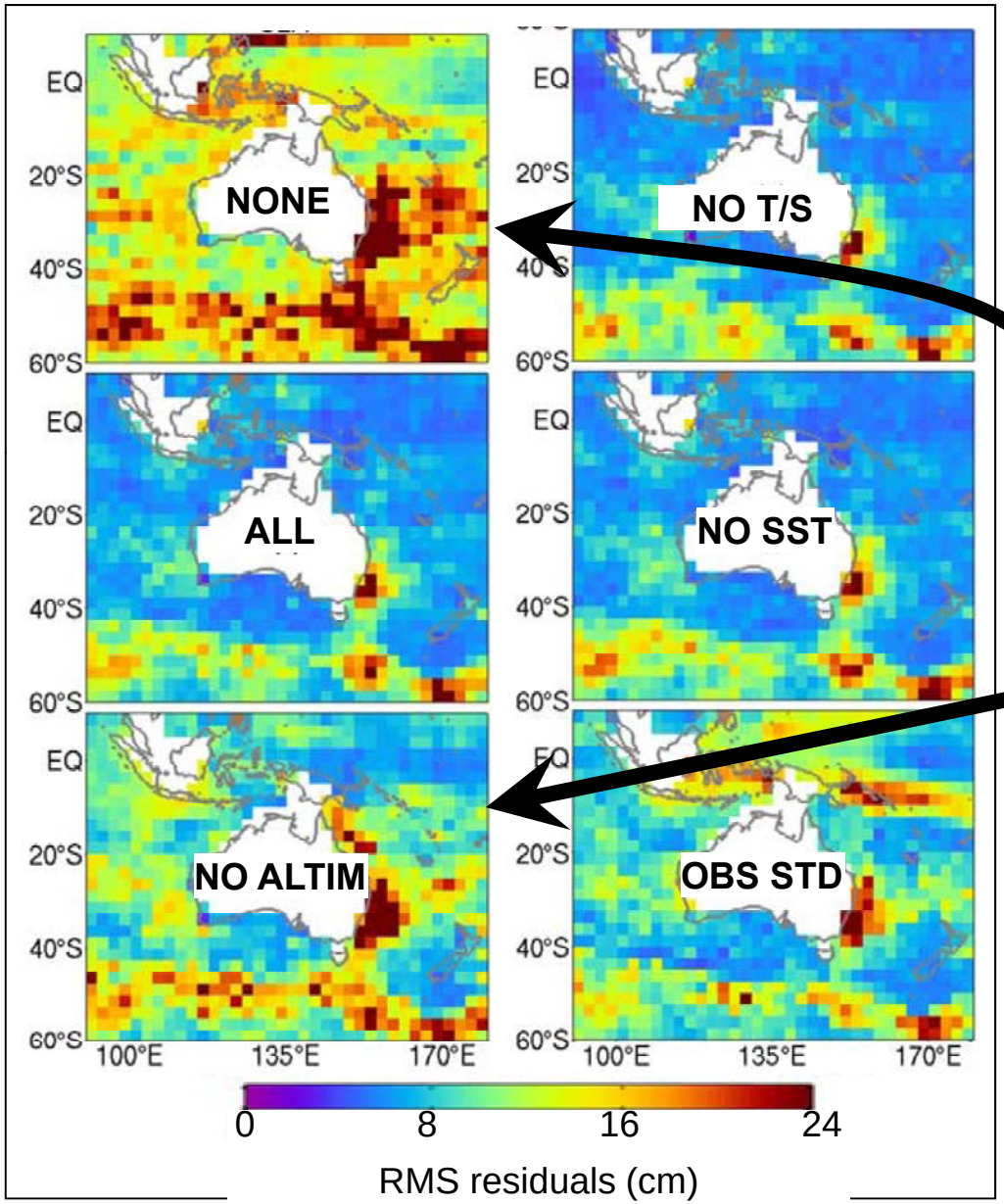
1/10º Bluelink system

6-month long OSEs starting December 2005

Oke and Schiller (2007; *GRL*)

www.cmar.csiro.au/staff/oke/

Complimentary data types: mesoscale prediction



Estimated SLA Errors

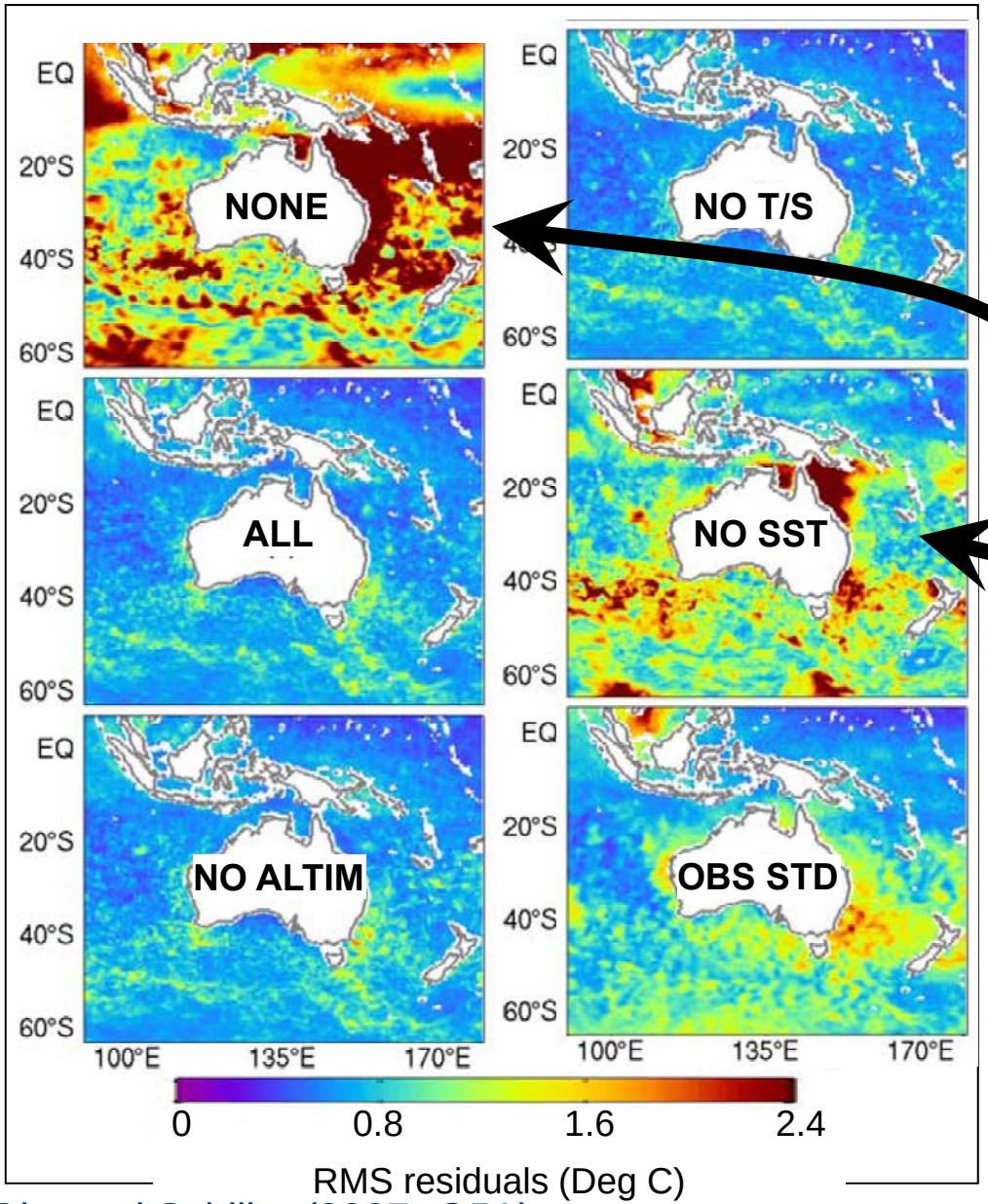
1/10º Bluelink system

6-month long OSEs starting December 2005

SST and Argo/XBT partially compensate for no ALTIM … but ALTIM is clearly necessary to represent the mesoscale

Oke and Schiller (2007; *GRL*)

Complimentary data types: mesoscale prediction



Estimated SST Errors

1/10º Bluelink system

6-month long OSEs starting December 2005

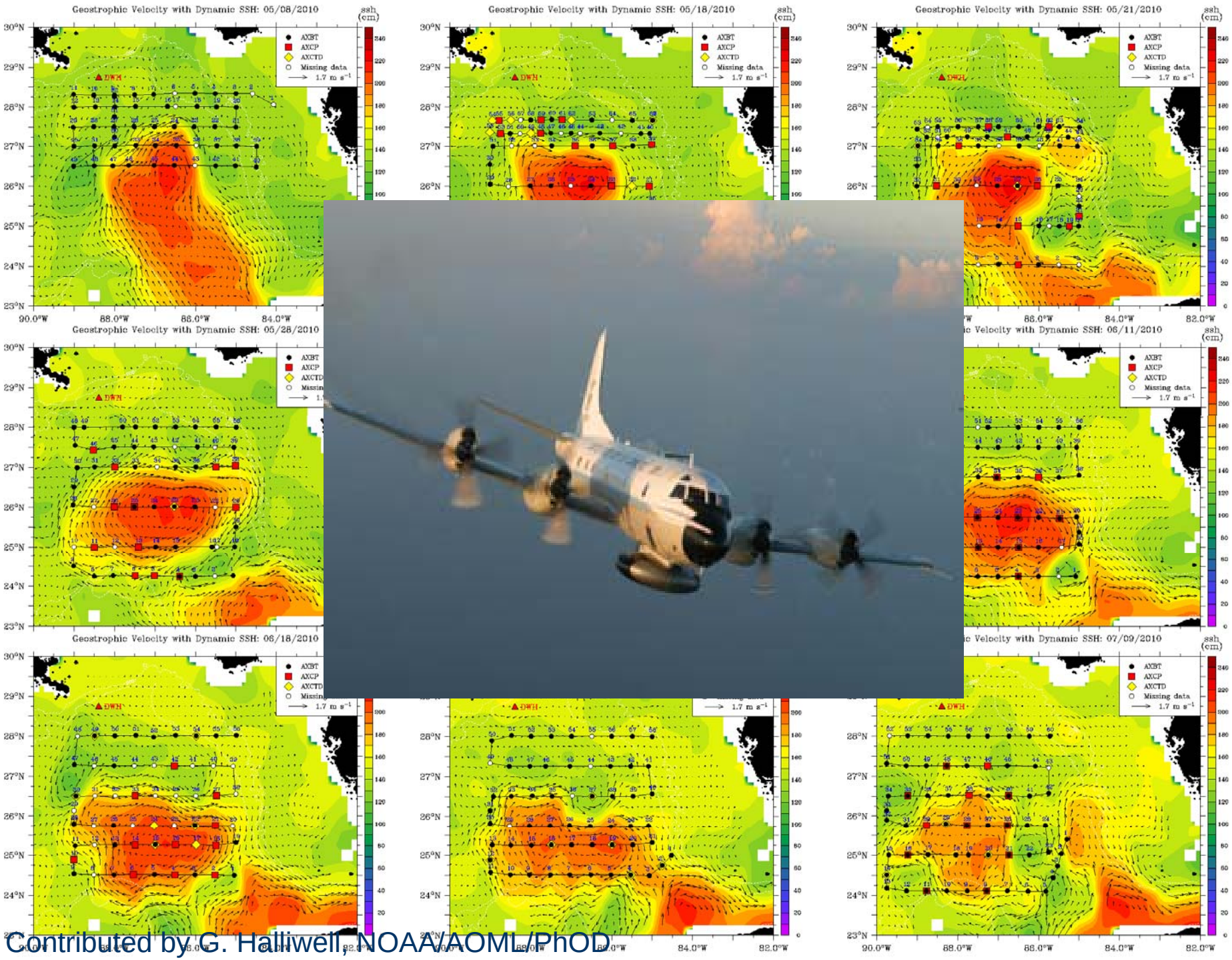
Argo/XBT partially compensates for no SST … but not over wide shelfs and shallow seas

Oke and Schiller (2007; *GRL*)

www.cmar.csiro.au/staff/oke/

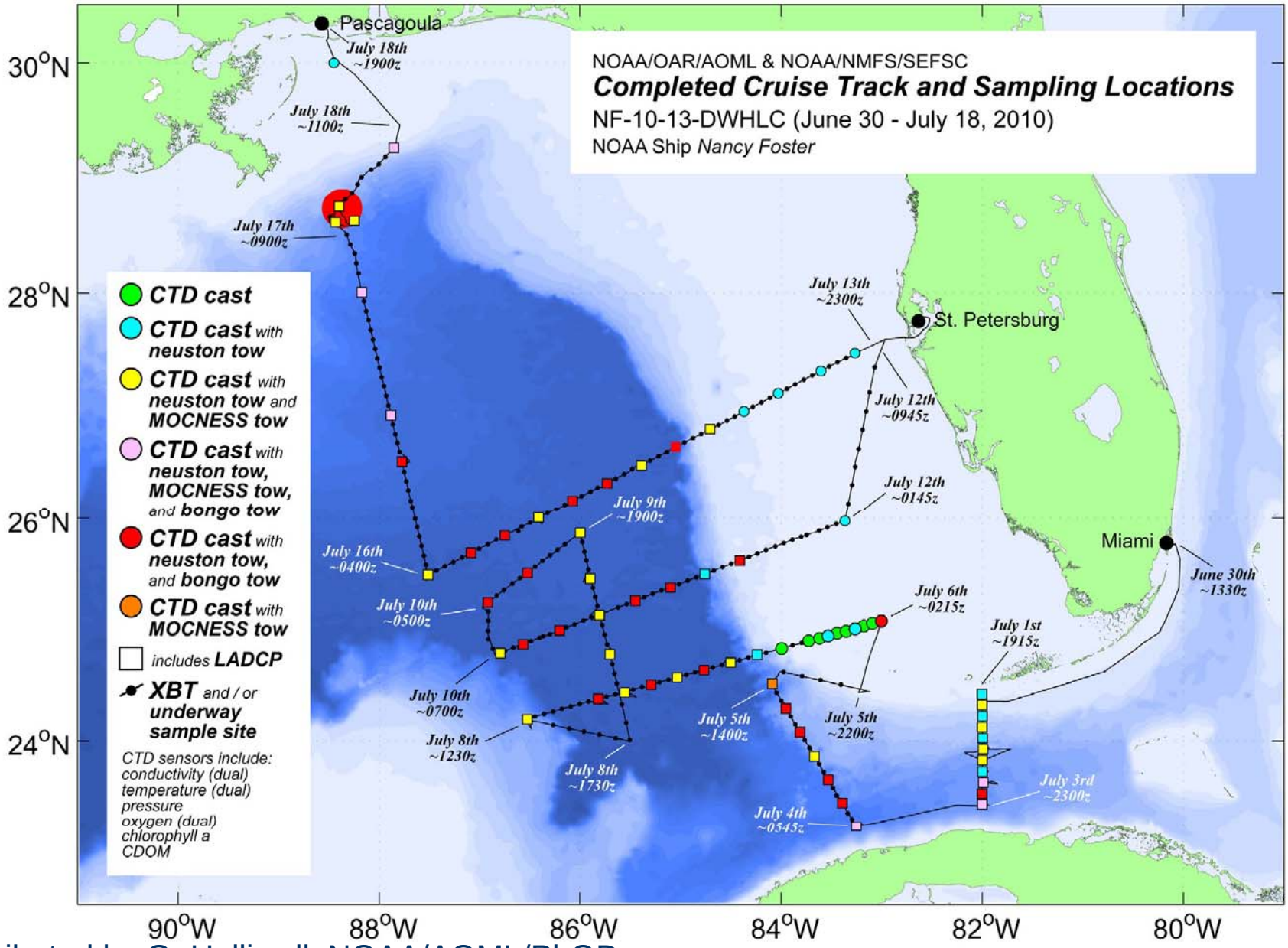
OSEs using HYCOM after the DWH Oil spill

Halliwell et al. (NRL & NOAA)



Contributed by G. Halliwell, NOAA/AOML/PhOD

From Nancy Foster Cruise Report (NOAA/AOML/PhOD)



Contributed by G. Halliwell, NOAA/AOML/PhOD

www.cmar.csiro.au/staff/oke/

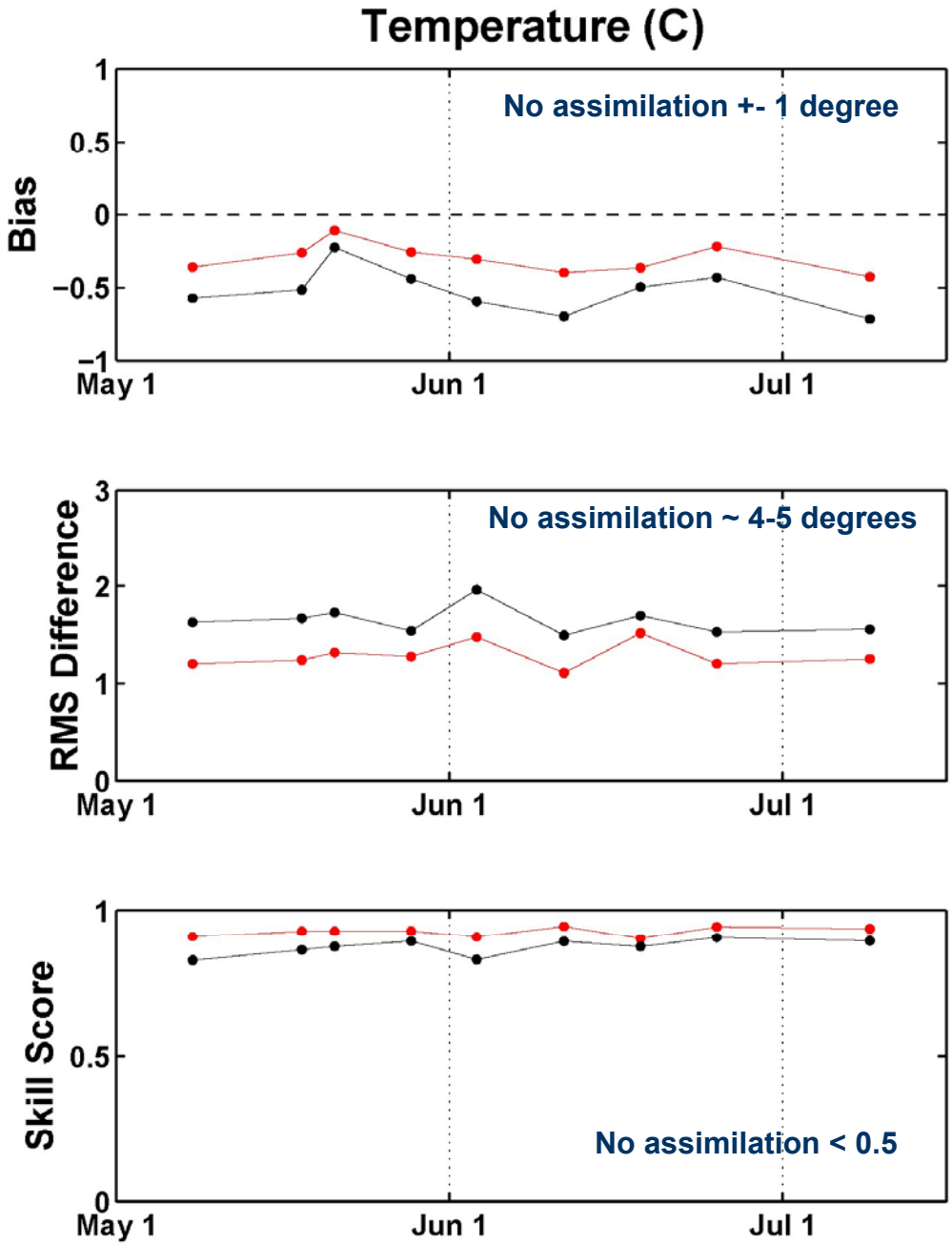
Impact of P-3 Observations on Ocean Analyses

Collaboration between AOML and NRL-Stennis

- NRL ran two experiments with the 1/25° regional HYCOM:
  1. Assimilate all observations
  2. Deny only the P3 observations

- Critical issues affecting this evaluation:
  - Results depend on choices of model and DA scheme
  - Impact of update cycle
  - Impact of relative weighting of synthetic T,S profiles derived from altimetry vs. *in-situ* T,S profiles

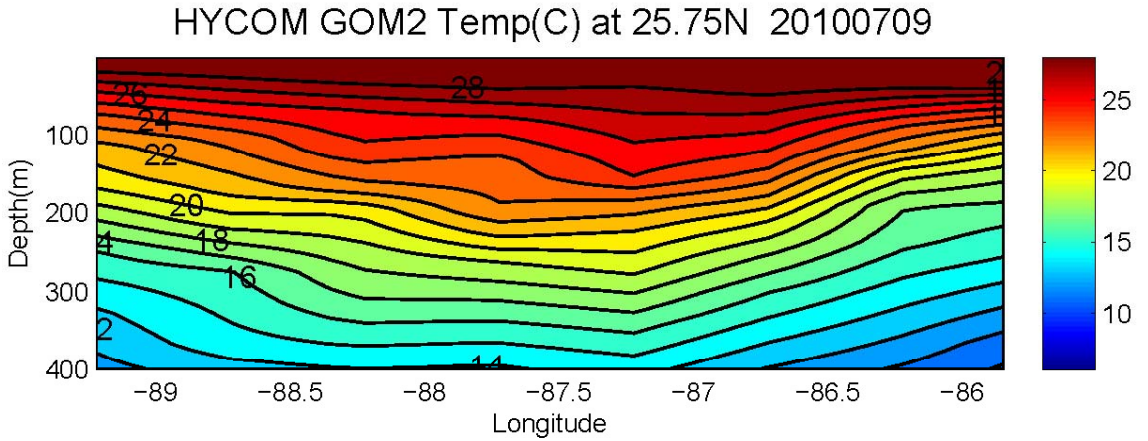
Contributed by G. Halliwell, NOAA/AOML/PhOD



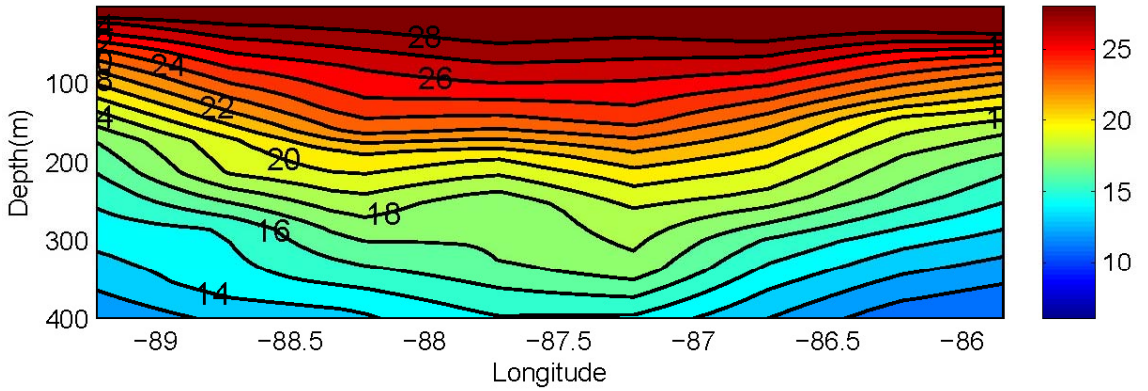
RED: With P3 assimilation

BLACK: No P3 assimilation

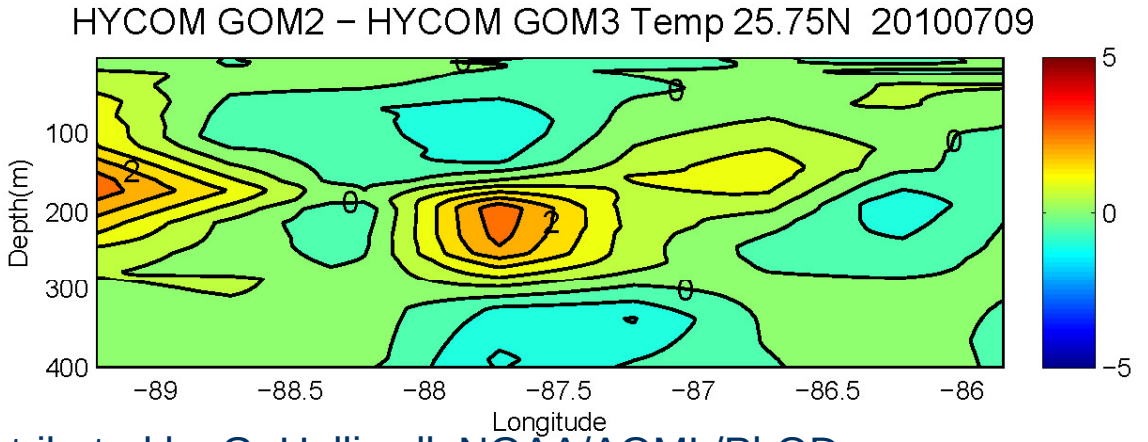
Contributed by G. Halliwell, NOAA/AOML/PhOD



T (°C), GoM HYCOM With P-3 Assimilation



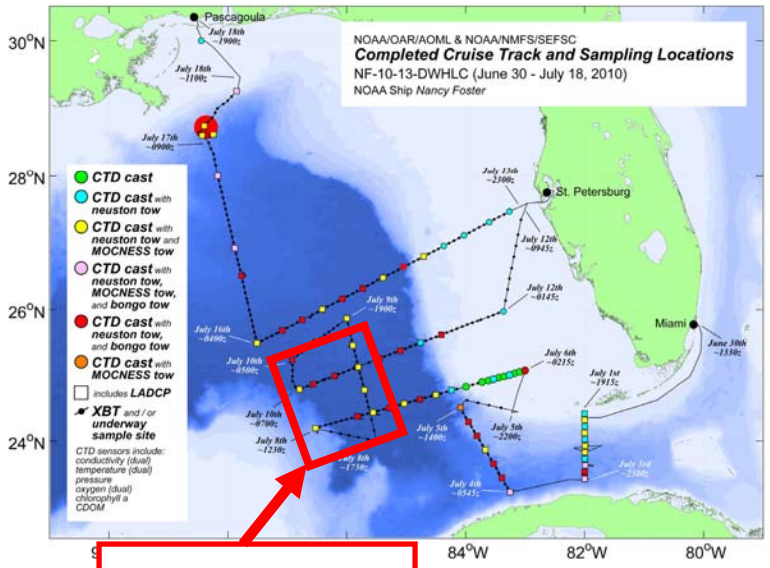
T (°C), GoM HYCOM Without P-3 Assimilation



ΔT, Impact of P-3 Assimilation (0.5°C contour interval)

Contributed by G. Halliwell, NOAA/AOML/PhOD

Error Analysis, Nancy Foster T Profiles, 9 July



8-10 July

Temperature, 30 – 360 m

Experiment	Bias (°C)	RMS Diff. (°C)	Skill Score
P-3 Profiles Assimilated	-1.11	1.41	0.88
P-3 Profiles Denied	-1.18	1.79	0.84
No Data Assimilation	-0.40	4.5	0.31

20°C isotherm depth

Experiment	Bias (°C)	RMS Diff. (m)	Skill Score
P-3 Profiles Assimilated	-21.1	35.8	0.09
P-3 Profiles Denied	-24.3	44.3	< 0
No Data Assimilation	19.3	89.5	< 0

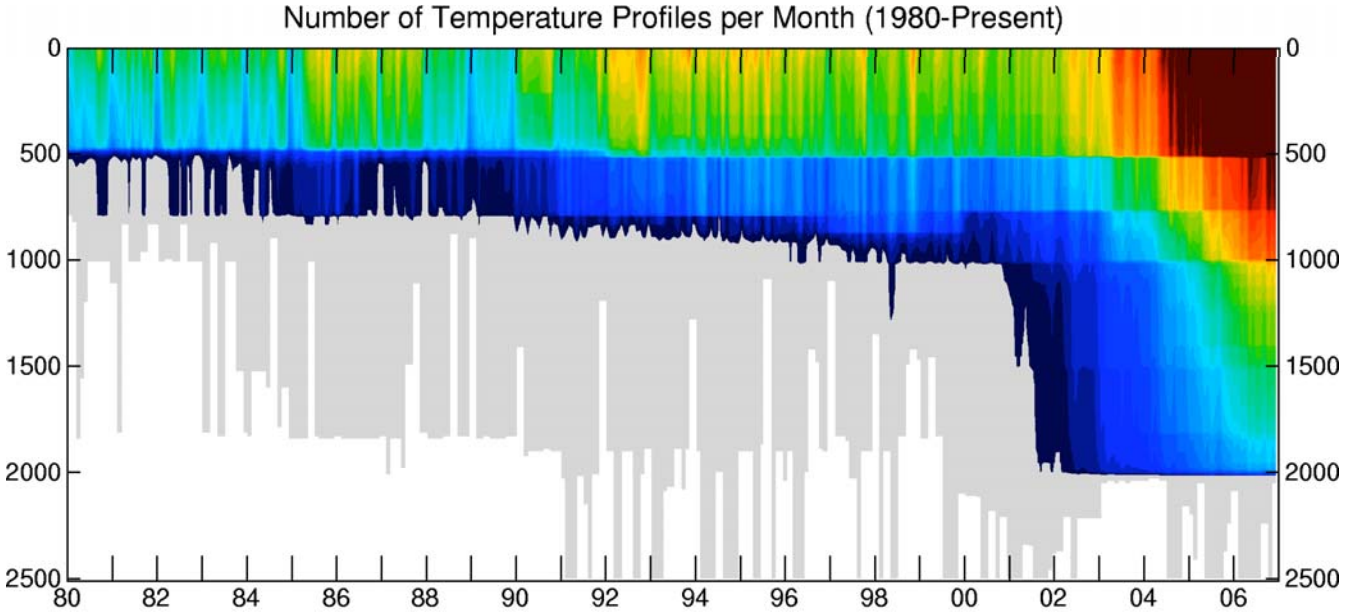
Contributed by G. Halliwell, NOAA/AOML/PhOD

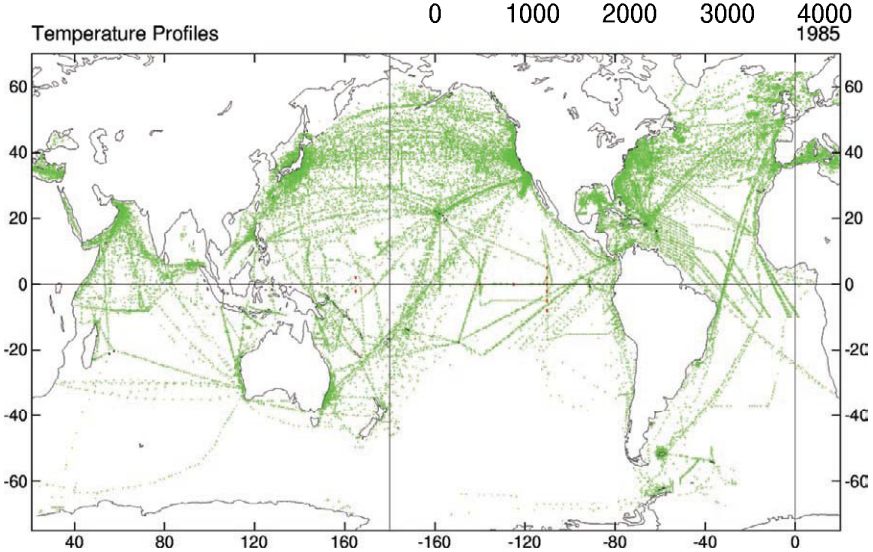
www.cmar.csiro.au/staff/oke/

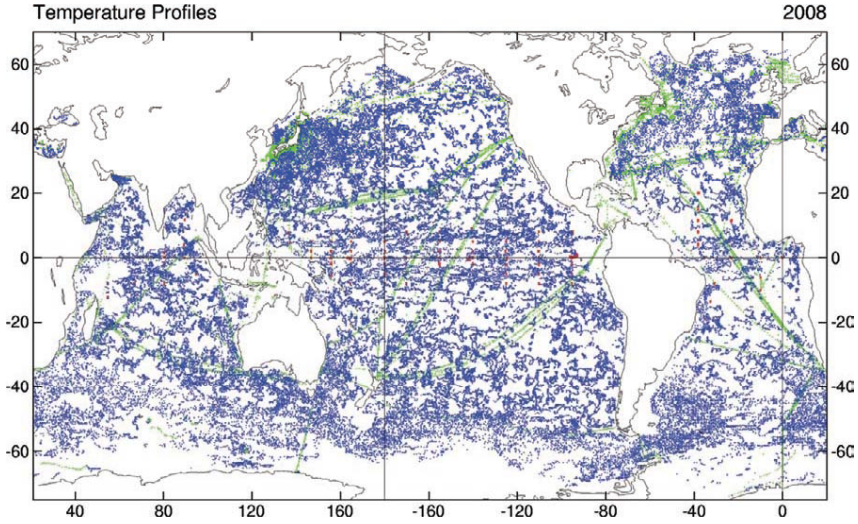
Inter-comparisons of intermediate-resolution reanalyses

Xue et al.

In Situ Observations



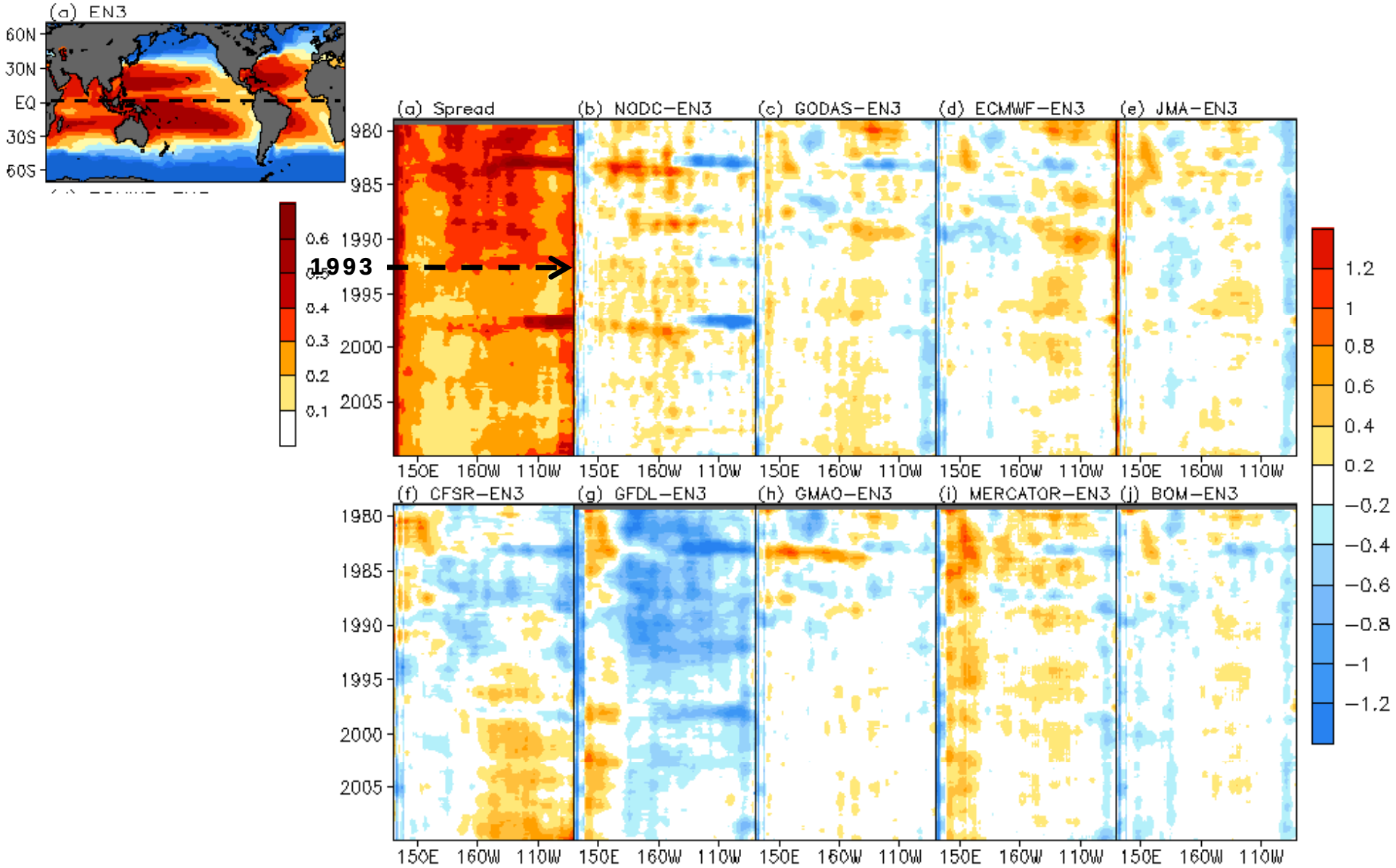




Contributed by Y. Xue, NOAA/NCEP – from Saha et al. (2010)

www.cmar.csiro.au/staff/oke/

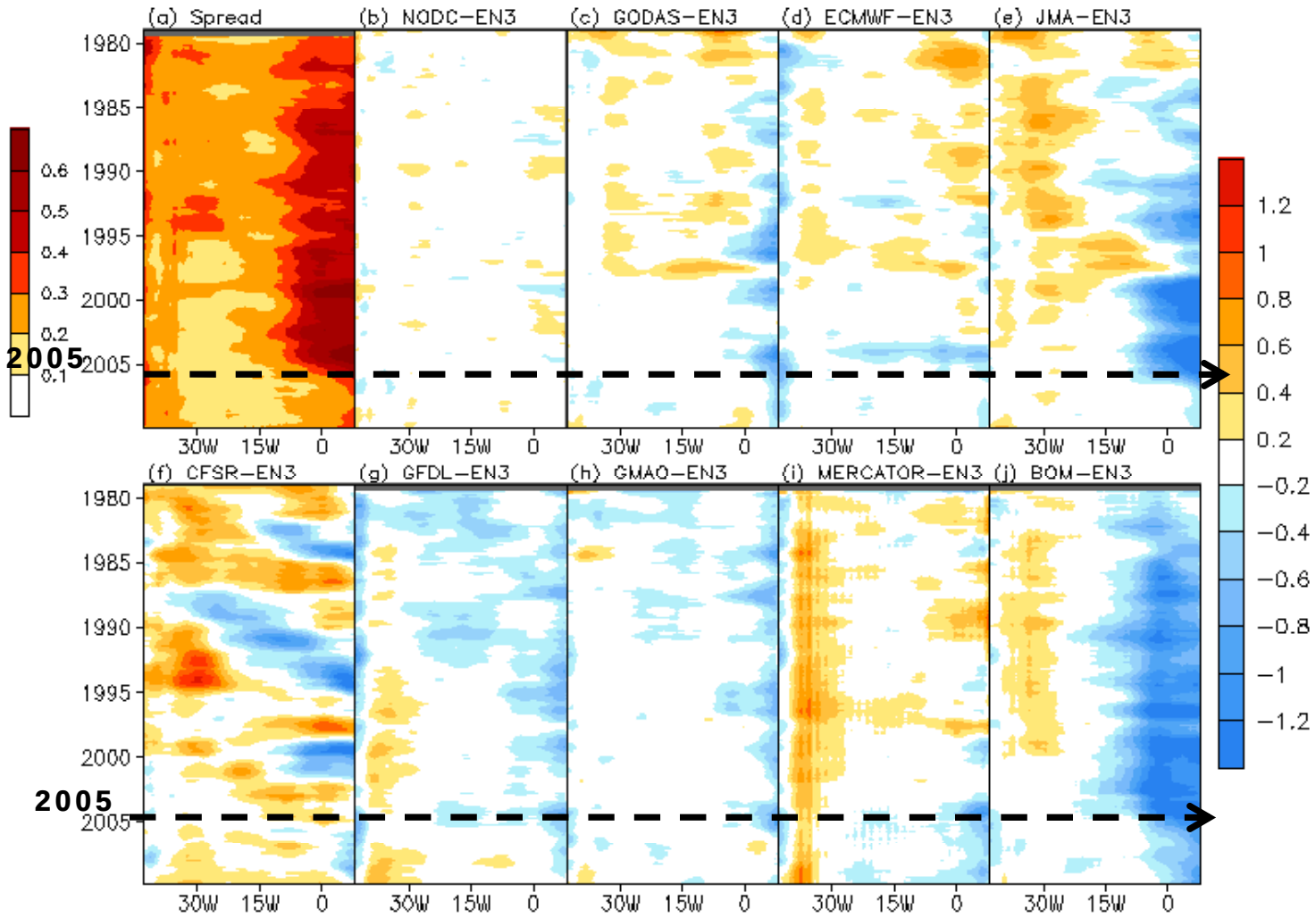
Inter-comparison of CLIVAR systems: HC300 in Equatorial Pacific (2°S-2°N)



Contributed by Y. Xue, NOAA/NCEP

www.cmar.csiro.au/staff/oke/

Inter-comparison of CLIVAR systems: HC300 in Equatorial Atlantic (2ºS-2ºN)



Contributed by Y. Xue, NOAA/NCEP

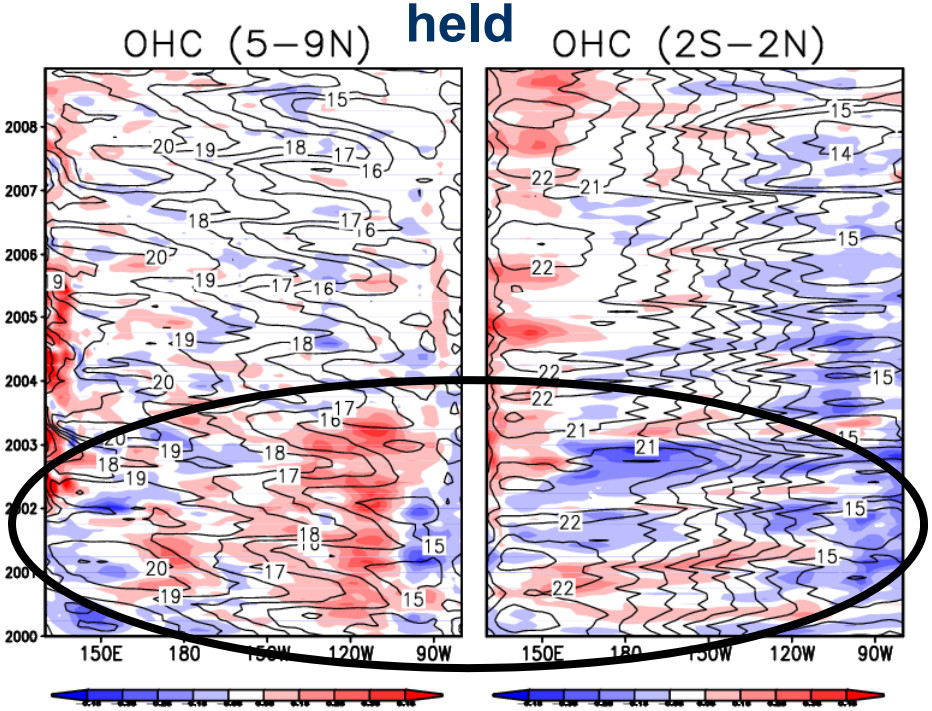
www.cmar.csiro.au/staff/oke/

OSEs using JMA/MRI seasonal prediction system

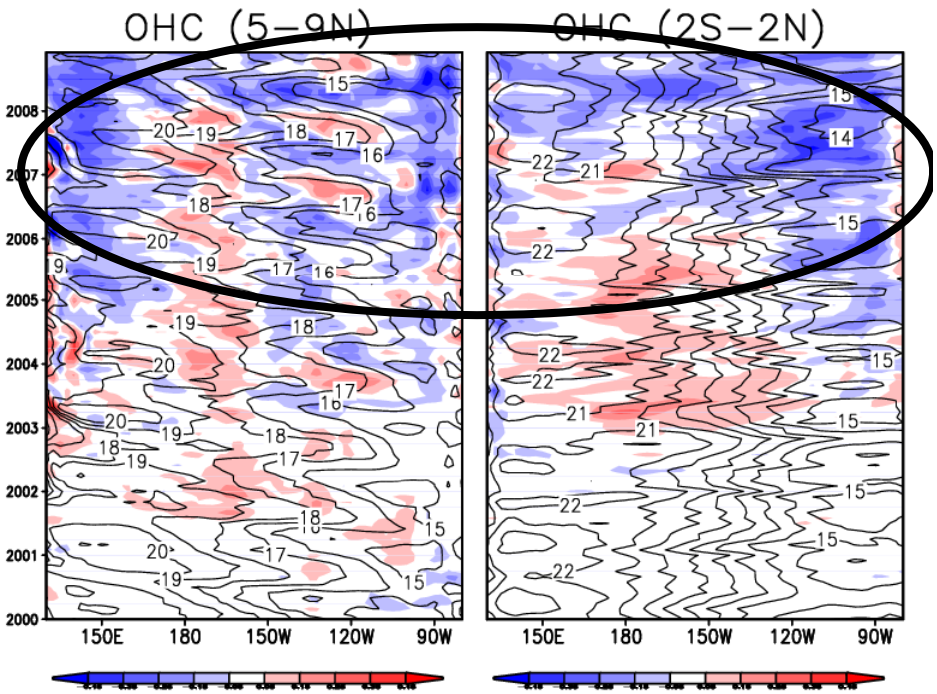
Fujii et al.

OSEs using JMA/MRI system

Difference when TAO/TRITON data are with-held



Difference when Argo data are with-held

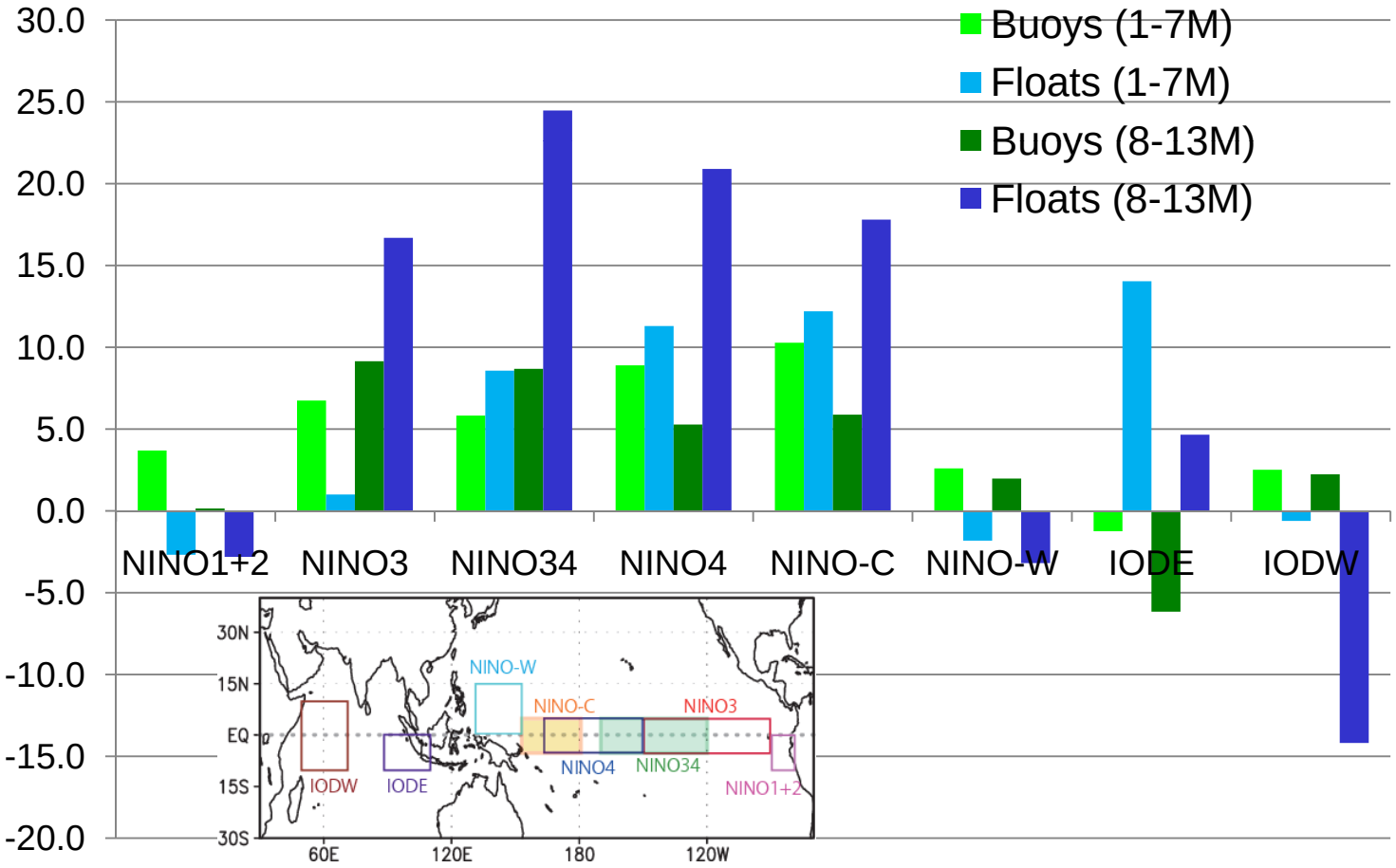


Impact of TAO data decreases, and Argo data increases, as the number of Argo floats increases

Contributed by Y. Fujjii, JMA/MRI

Impact of Argo and TAO data on JMA forecast skill

- With-holding Argo data degrades the skill of forecasts over 8-13 months by almost 25% in the Pacific Ocean
- With-holding TAO data degrades the skill of forecasts over 1-7 months by almost 15% in the Indian Ocean.



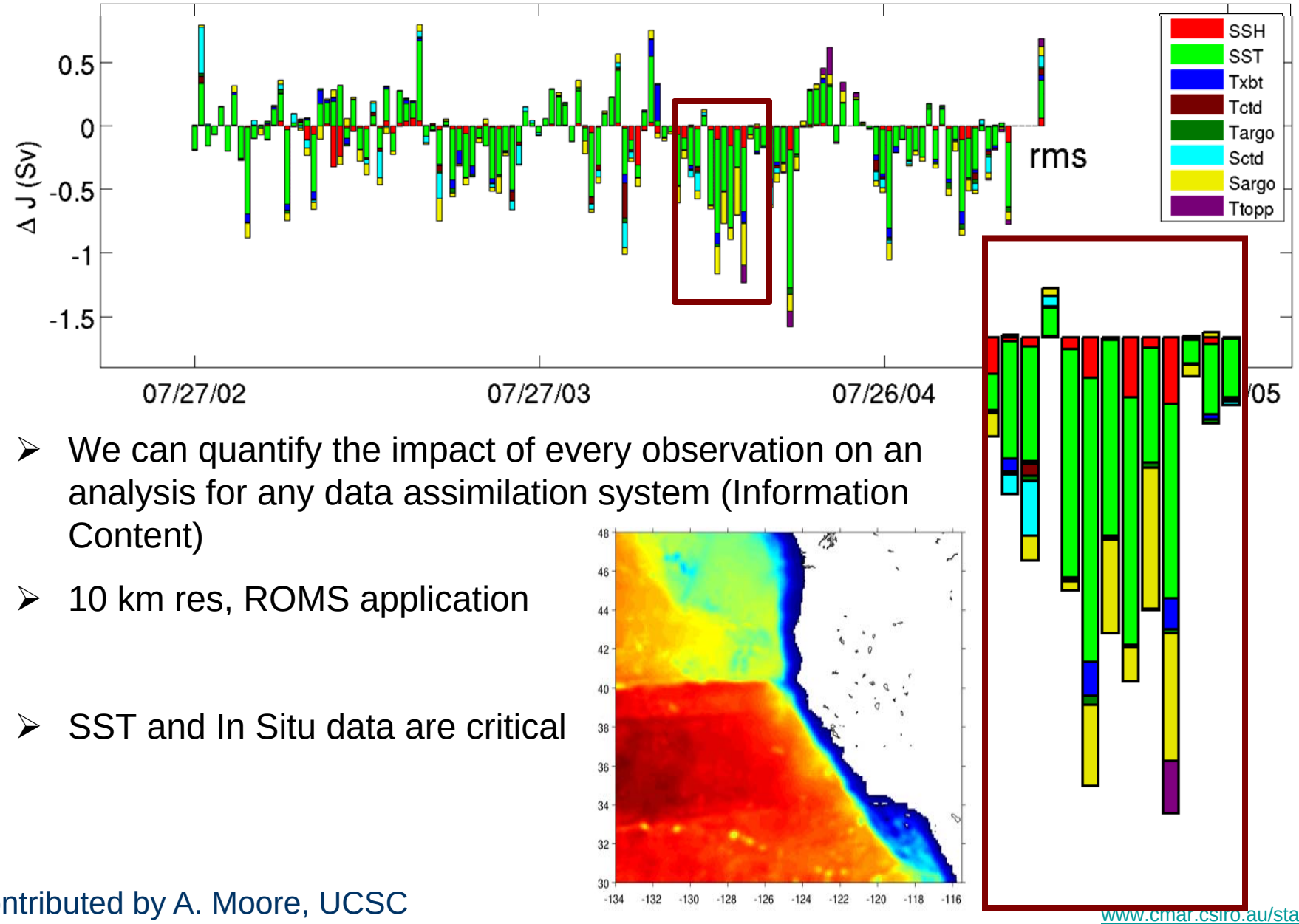
Contributed by Y. Fujjii, JMA/MRI

www.cmar.csiro.au/staff/oke/

Information content (analysis sensitivity) and forecast sensitivity using coastal model off California

Moore et al.

Data impacts on coastal model analyses and forecasts

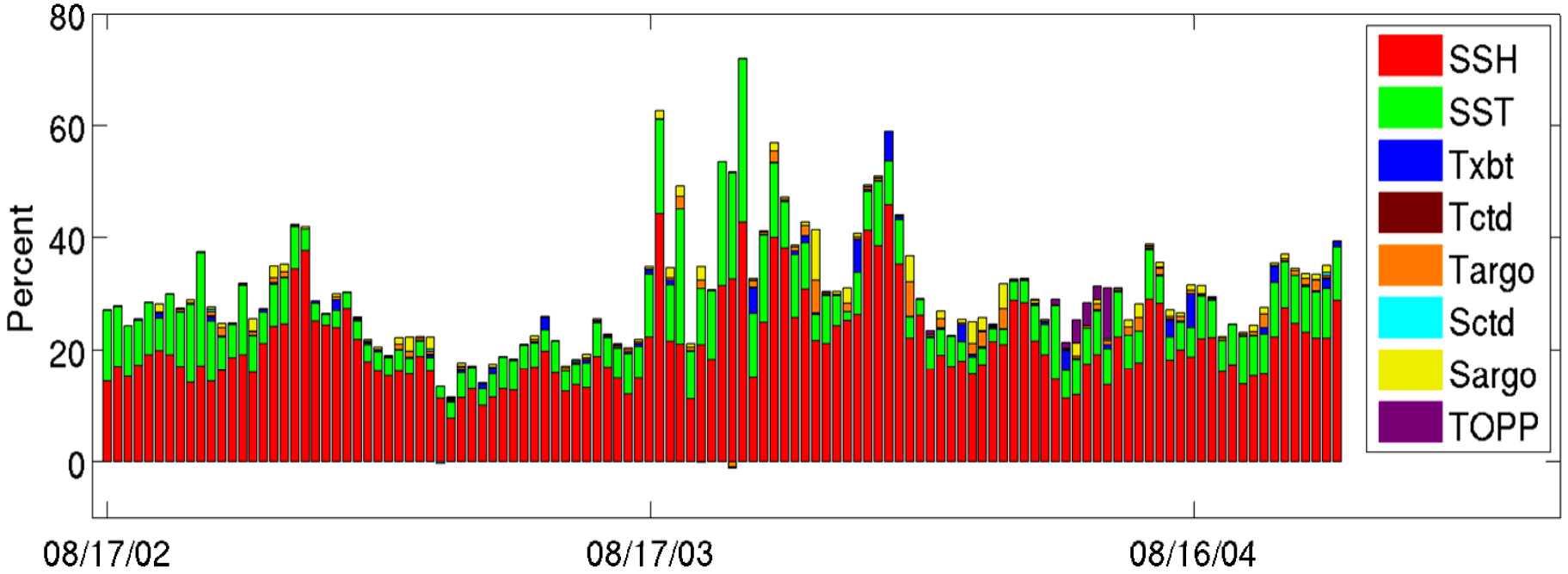


- We can quantify the impact of every observation on an analysis for any data assimilation system (Information Content)
- 10 km res, ROMS application
- SST and In Situ data are critical

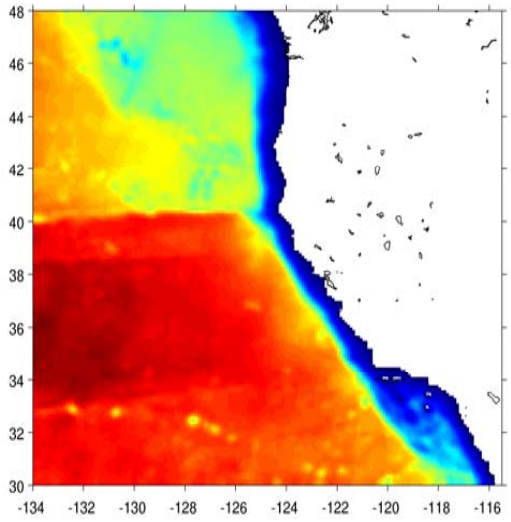
Contributed by A. Moore, UCSC

www.cmar.csiro.au/staff/oke/

Data impacts on coastal model analyses and forecasts



- Using a 4dVar system, we can quantify the impact of every observation on a forecast (Forecast sensitivity)
- 10 km res, ROMS application
- SSH data are critical



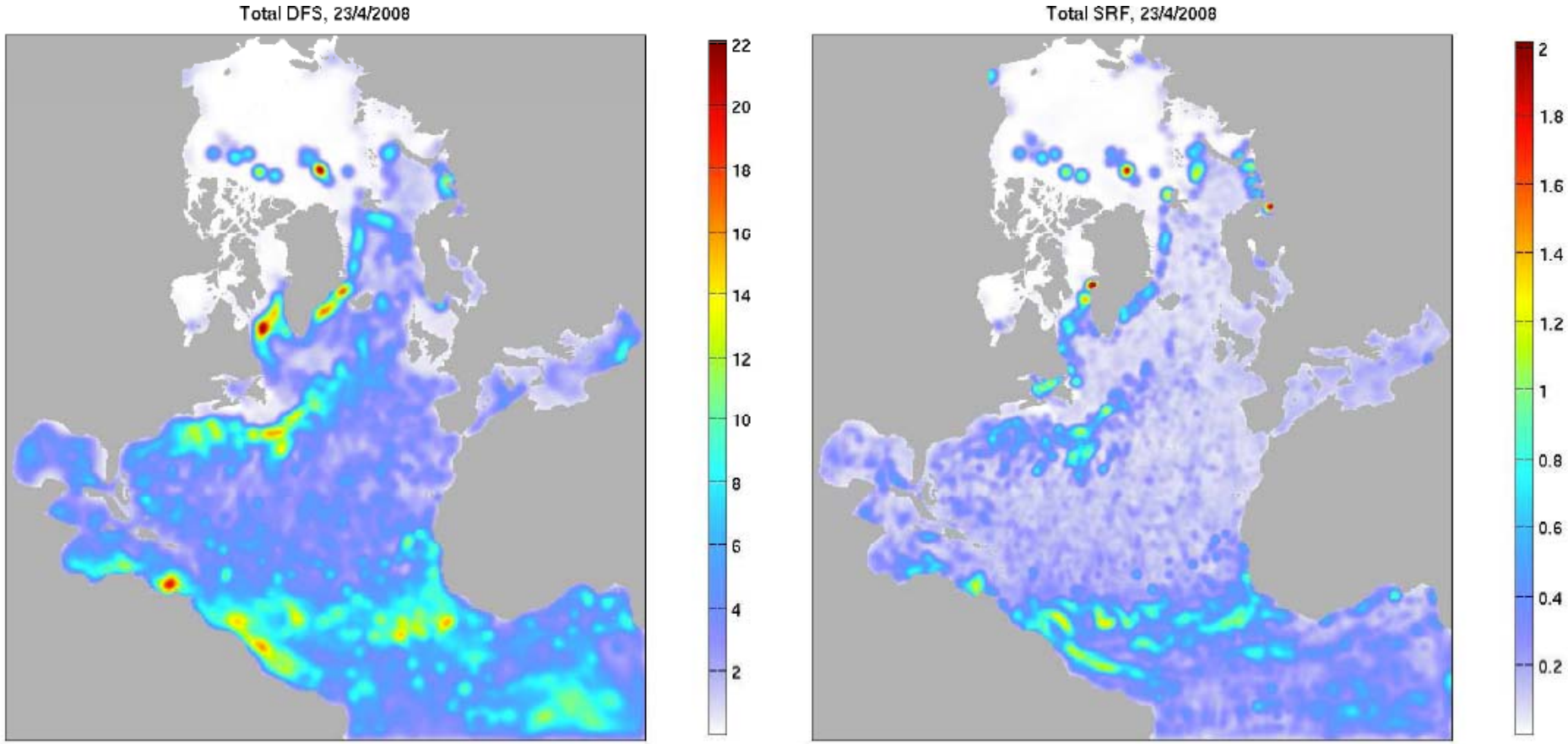
Contributed by A. Moore, UCSC

www.cmar.csiro.au/staff/oke/

Information content (analysis sensitivity) using the TOPAZ system

Sakov et al.

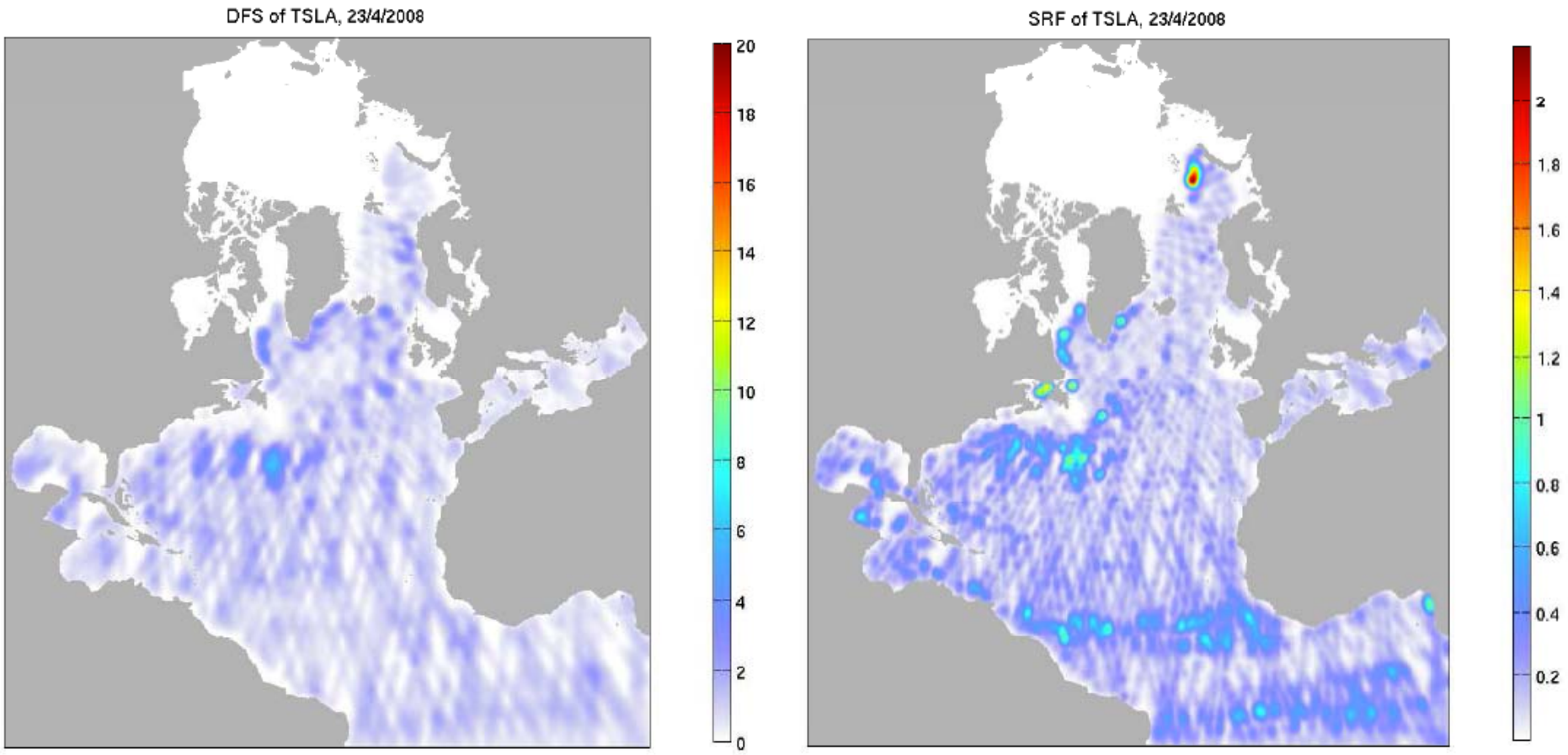
Data impact on TOPAZ reanalysis



Contributed by P. Sakov, NERSC

www.cmar.csiro.au/staff/oke/

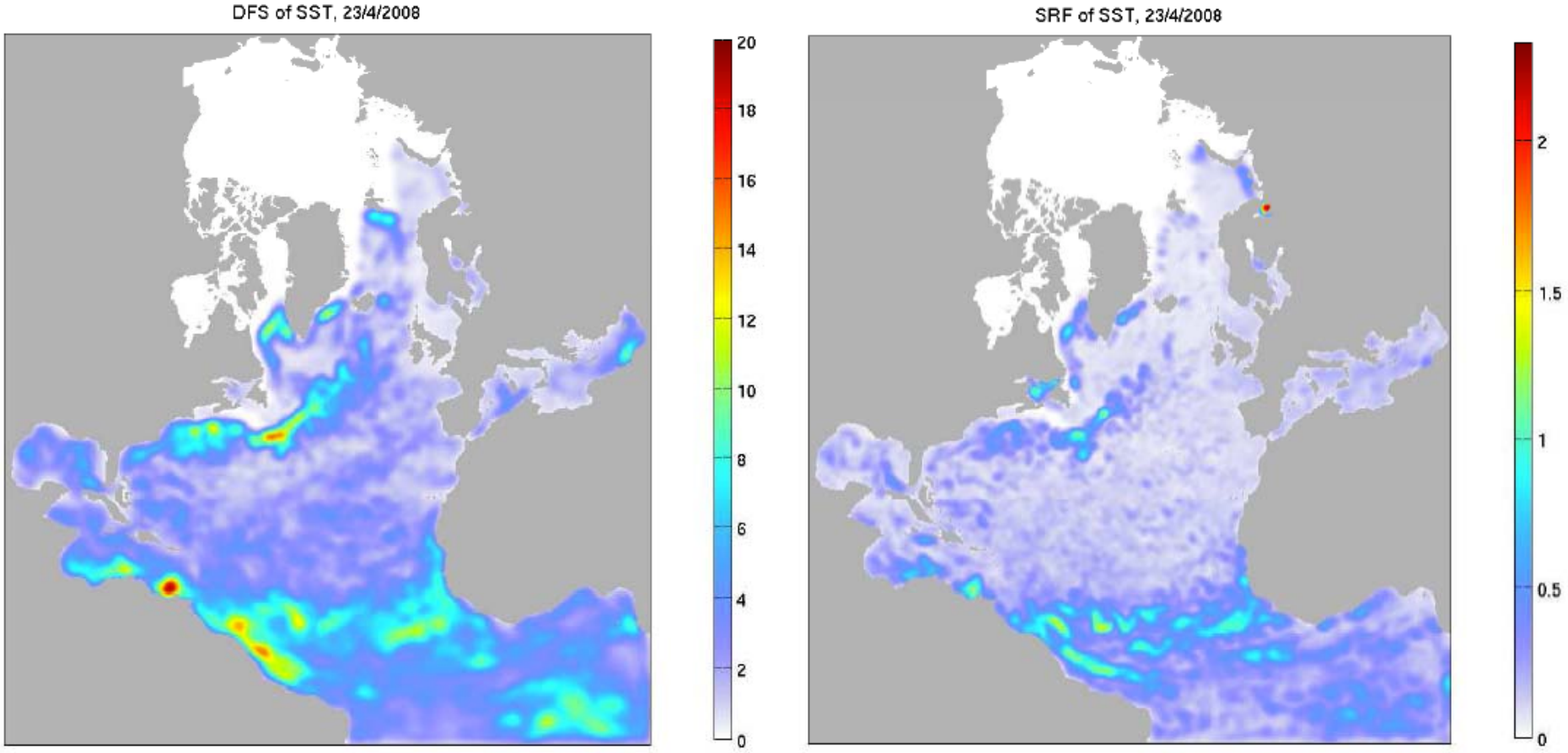
Data impact on TOPAZ reanalysis



Contributed by P. Sakov, NERSC

www.cmar.csiro.au/staff/oke/

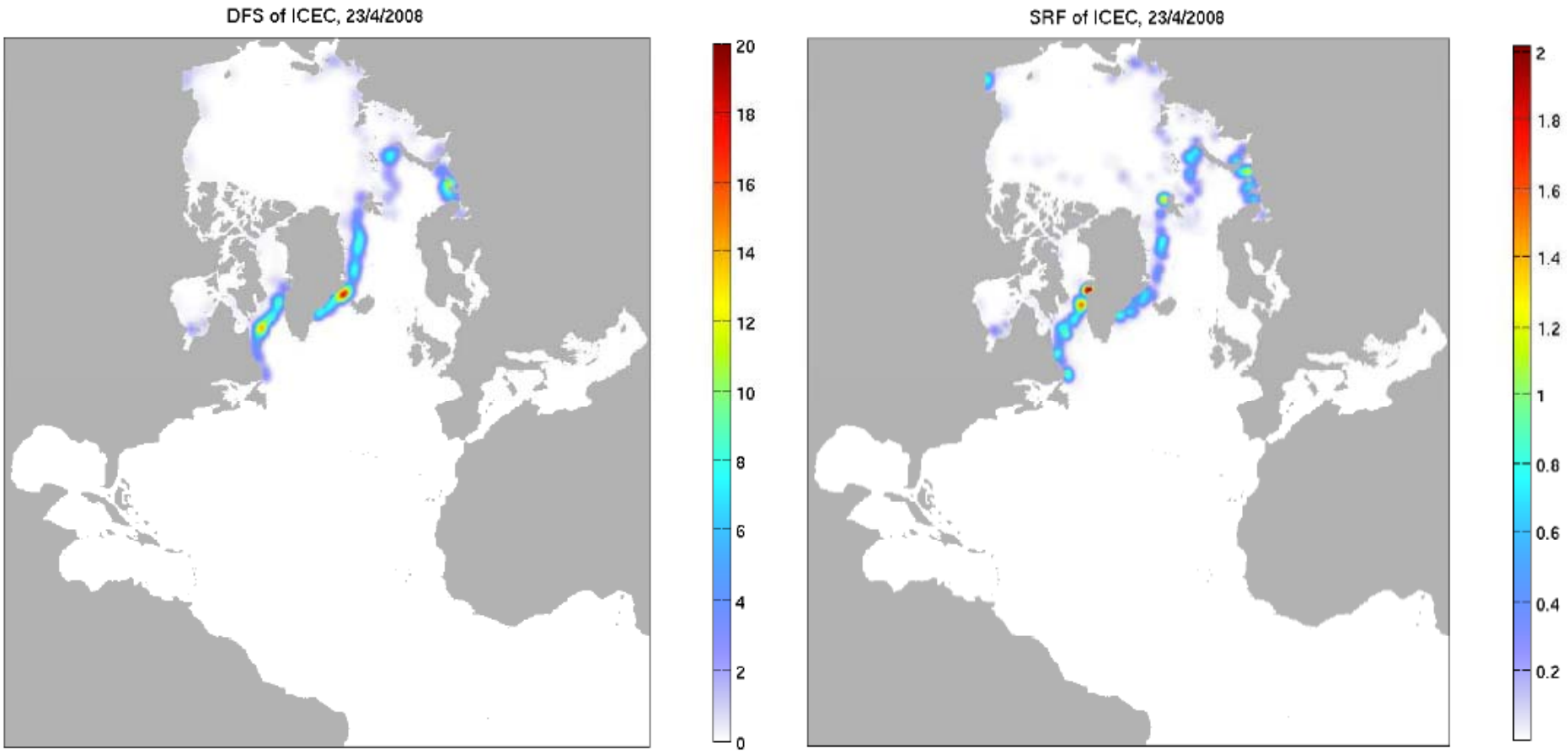
Data impact on TOPAZ reanalysis



Contributed by P. Sakov, NERSC

www.cmar.csiro.au/staff/oke/

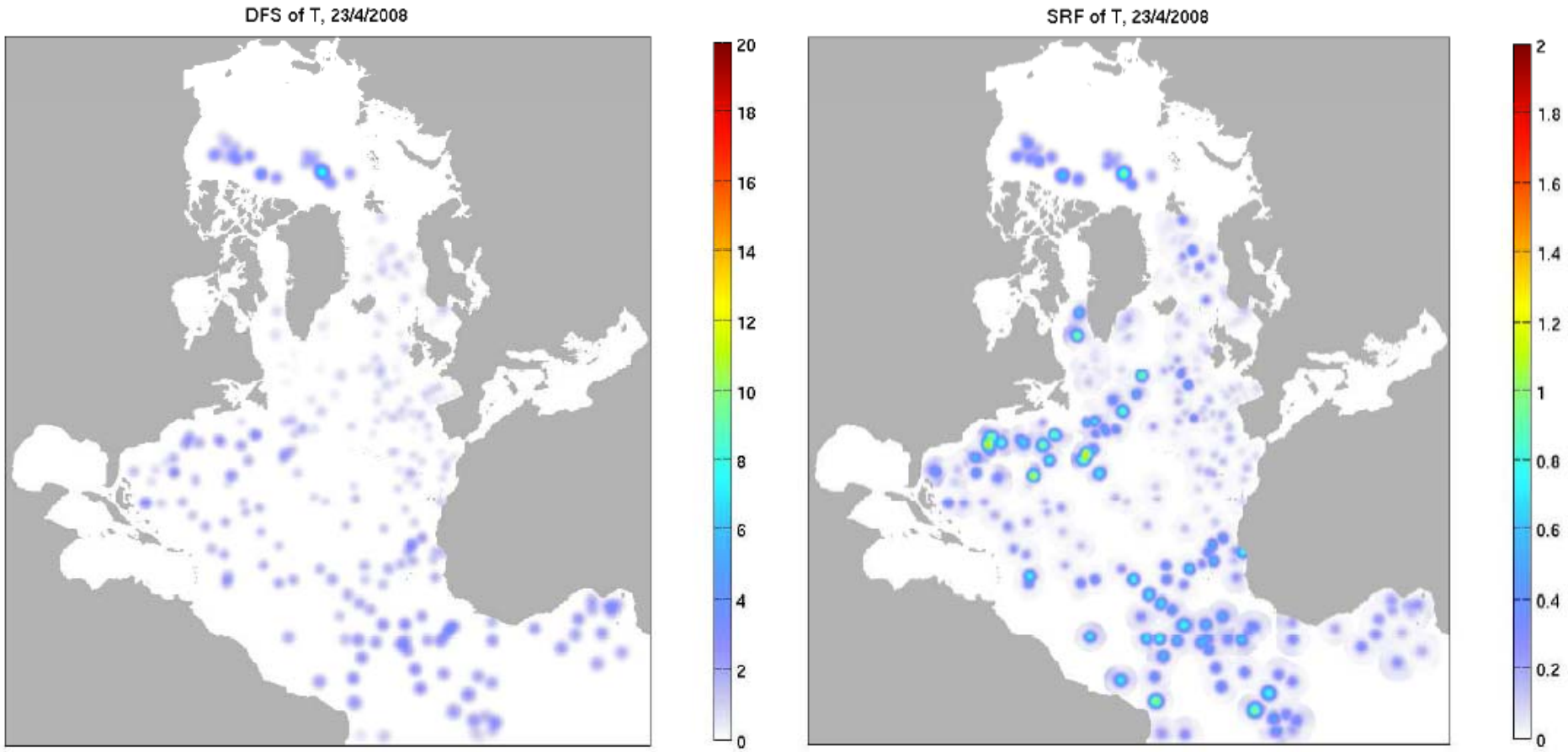
Data impact on TOPAZ reanalysis



Contributed by P. Sakov, NERSC

www.cmar.csiro.au/staff/oke/

Data impact on TOPAZ reanalysis



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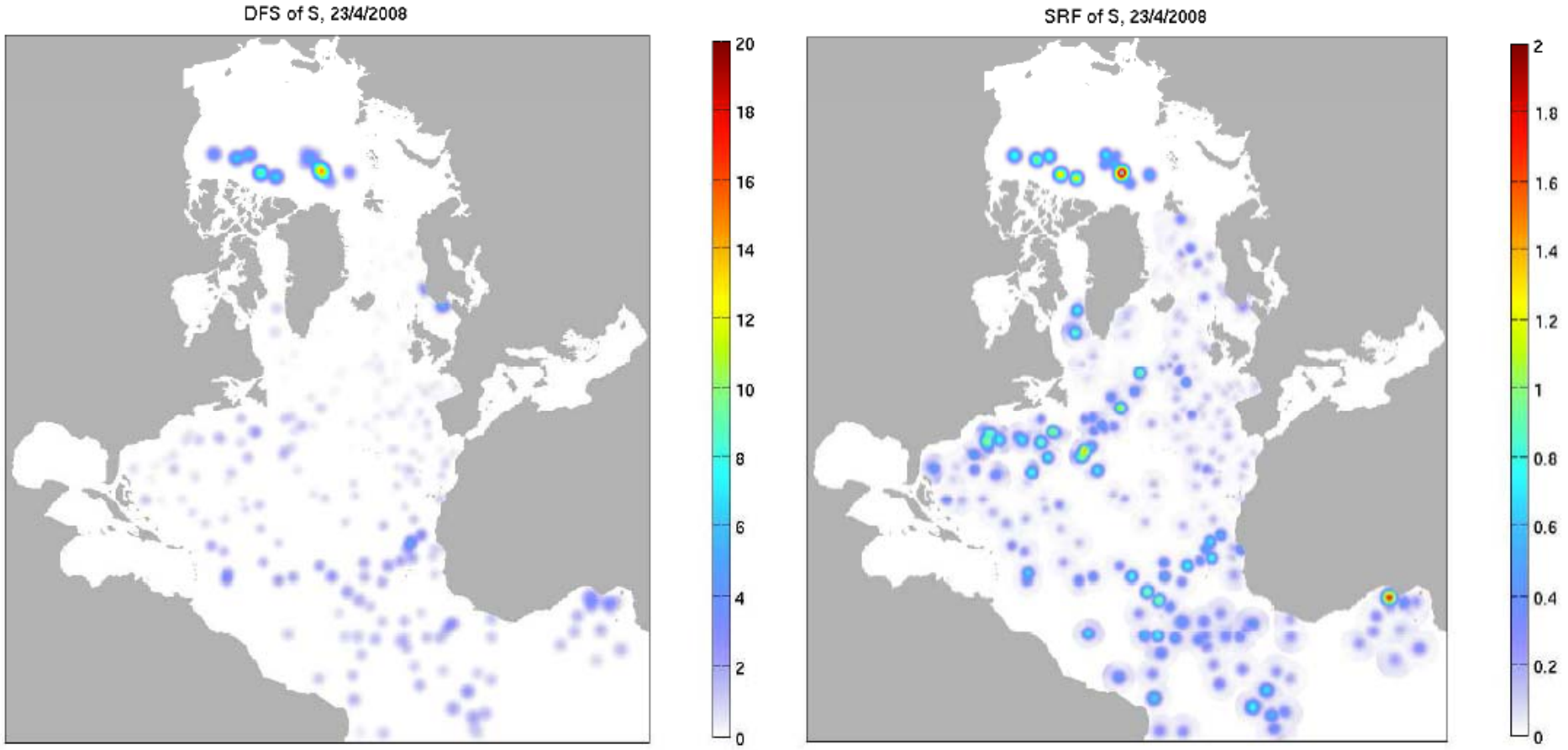

Contributed by P. Sakov, NERSC

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Evaluating options for altimeter constellations

Larnicol et al.

Altimeter constellations

3 x Nadir

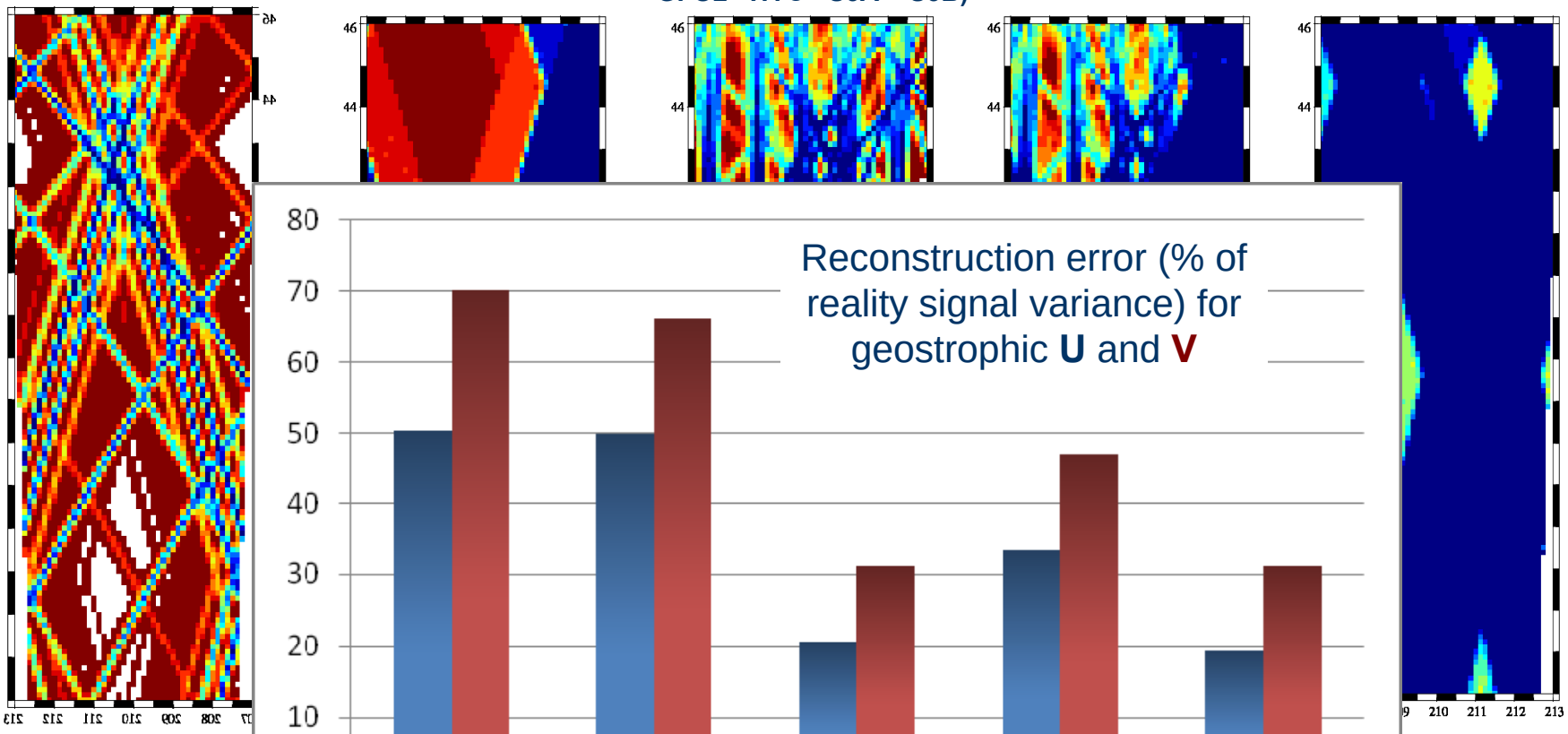
1x SWOT

11 x Nadir

(Iridium 6 + Jason-CS +GFO2+ HYC+ S3A + S3B)

1 x SWOT + 11 x Nadir

2 x SWOT



Contributed by G. Larnicol, CLS

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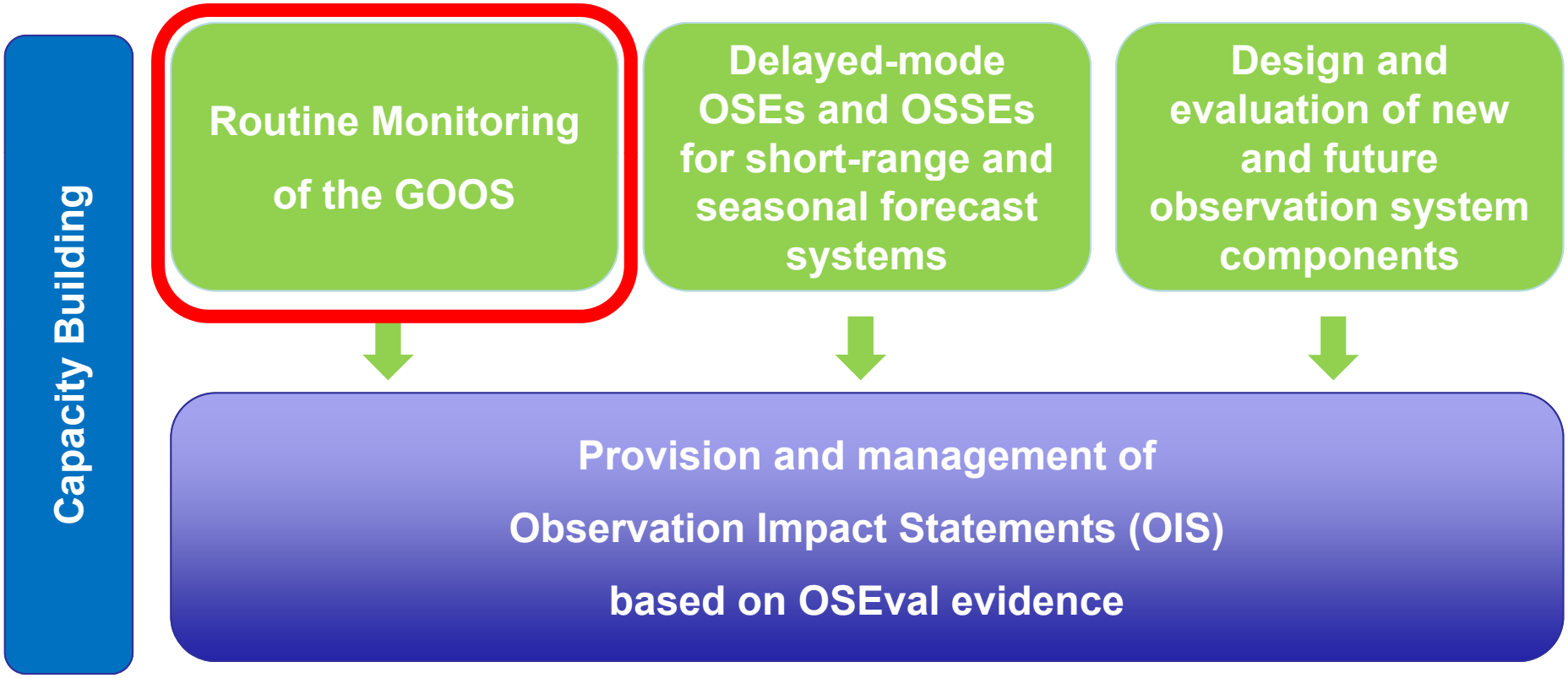
Observing System Evaluation Task Team (OSEval-TT)



www.cmar.csiro.au/staff/oke/

Responses to “observing system events”

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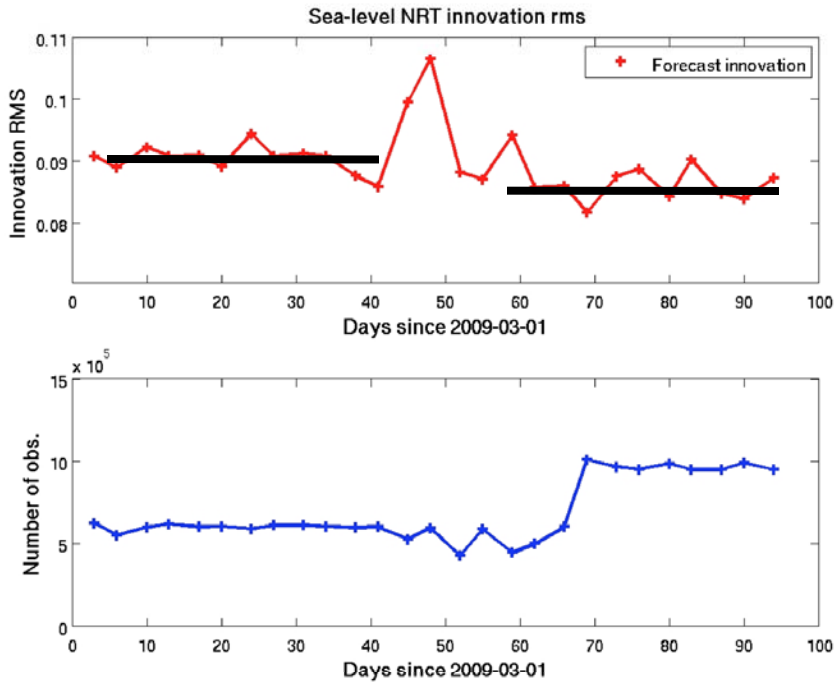

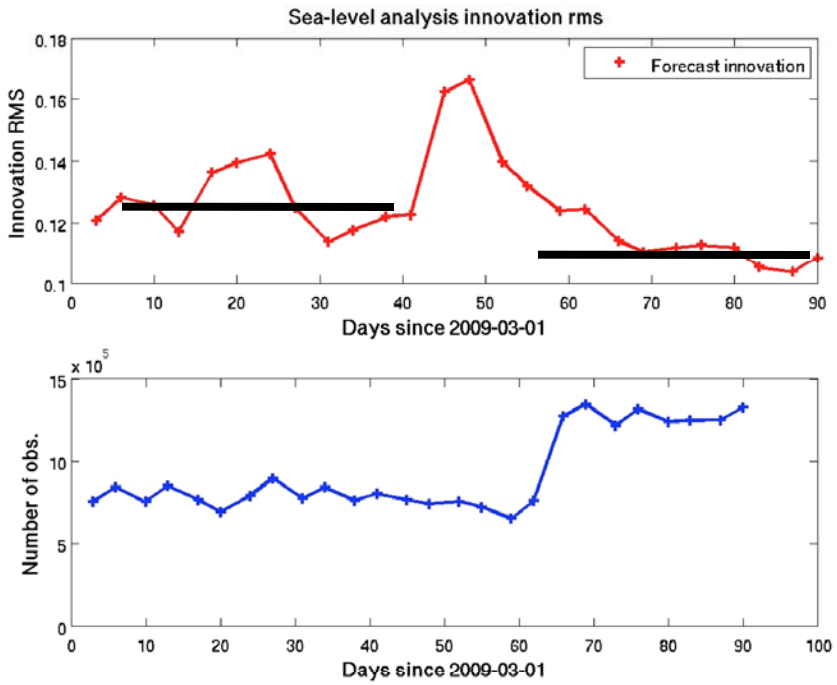

Contributed by G. Brassington, BoM

www.cmar.csiro.au/staff/oke/

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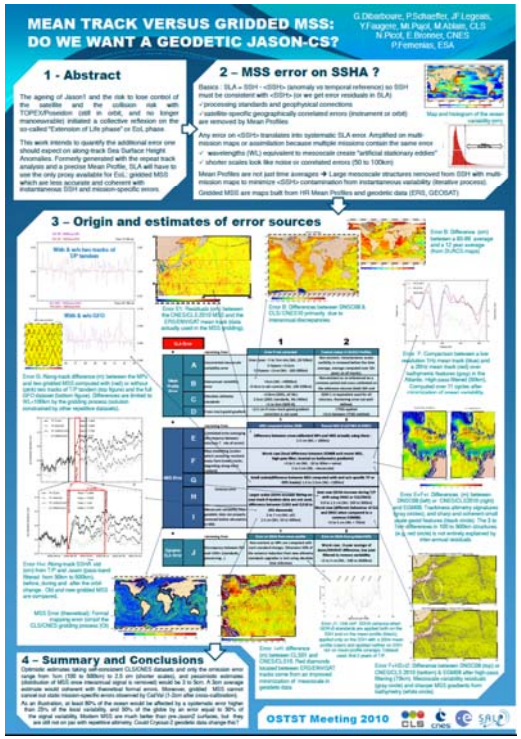

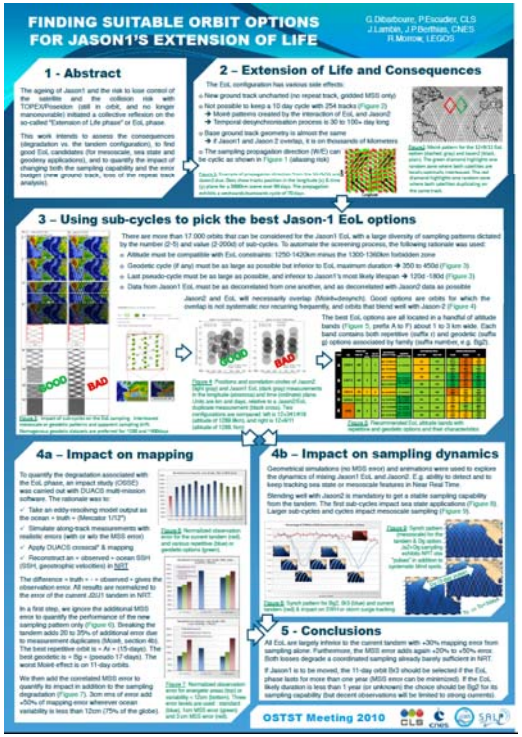

Contributed by G. Larnicol and G. Dibardoure, CLS

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Too ad hoc – we need to be more organised

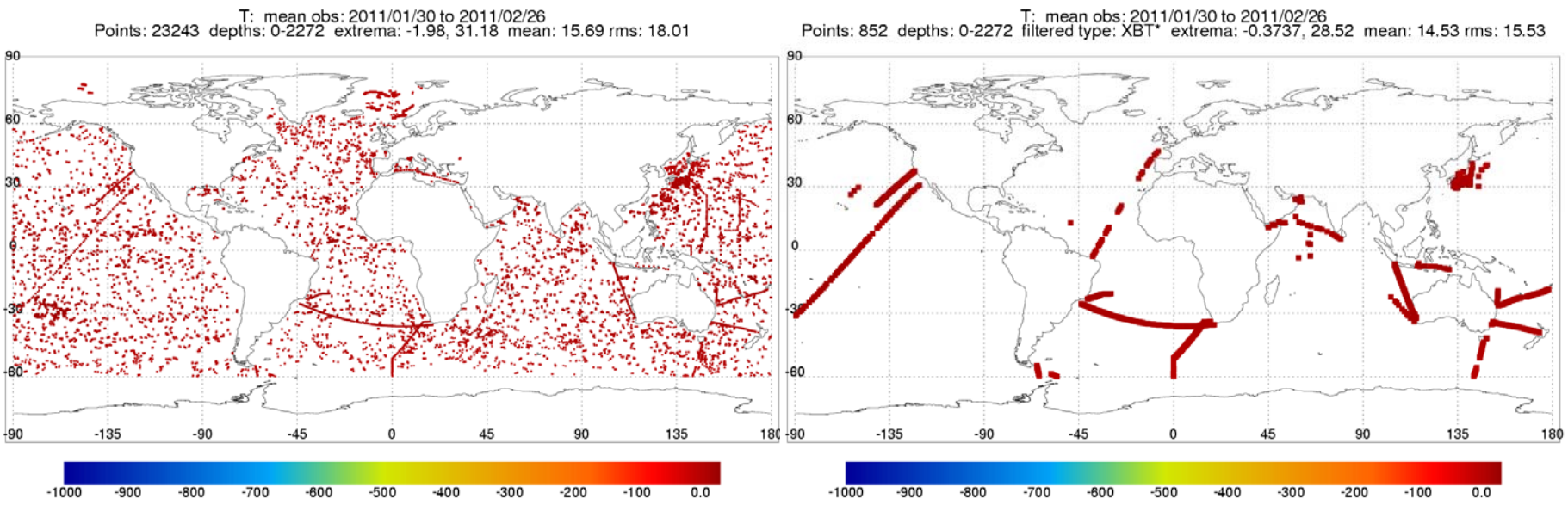
NRT OSEs

- Routinely run parallel forecast at operational centers and with-hold a different data each month:

Jan 2011	**Argo**	**Jul 2011**	**-**
Feb 2011	**XBT**	**Aug 2011**	**Microwave SST**
Mar 2011	**TAO**	**Sep 2011**	**Argo**
Apr 2011	**Jason-02**	**Oct 2011**	**XBT**
May 2011	**All altims**	**Nov 2011**	**TAO**
Jun 2011	**SST**	**Dec 2011**	**Jason-2**

- Quantify the impact of each data type on forecasts
- Multi-system approach
- Rotating data types each month

NRT OSEs – with-holding XBT data (February 2011)



Not many... 3.7% of total profile type observations

Contributed by D. Lea, UKMet Office

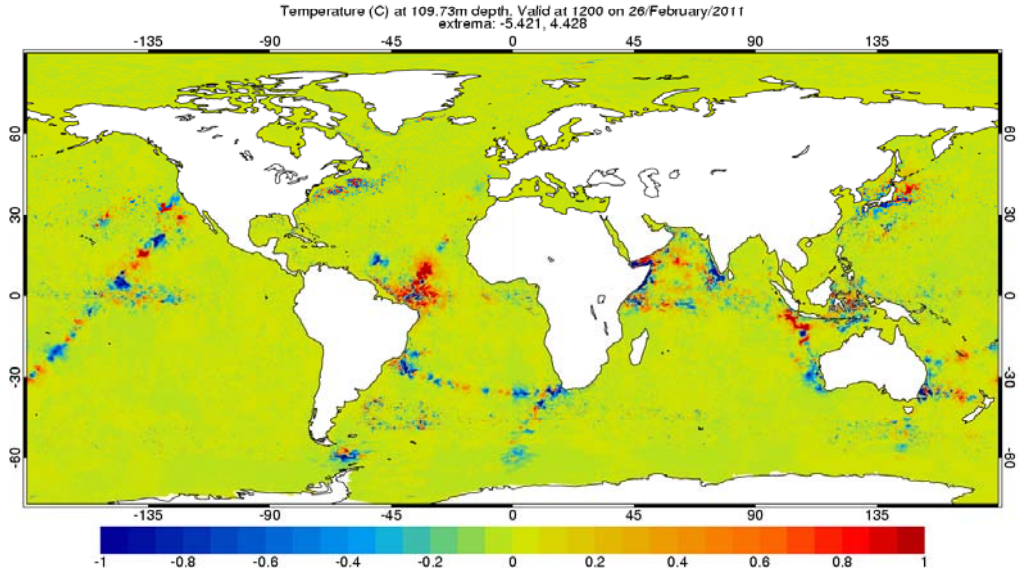
www.cmar.csiro.au/staff/oke/

NRT OSEs – with-holding XBT data (February 2011)

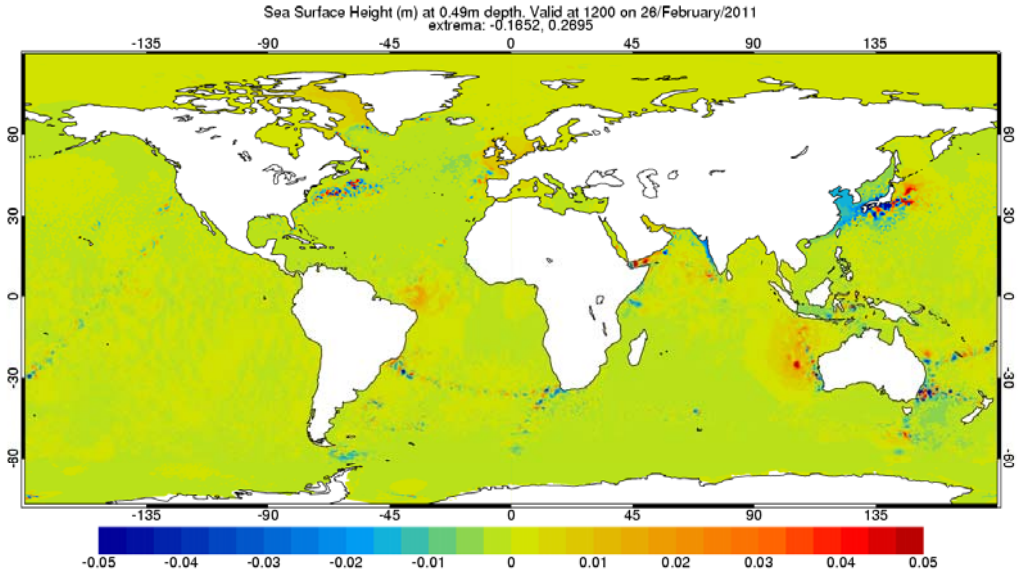
100m temp

Oper minus OSE

I.e. shows the effect of assimilating XBT



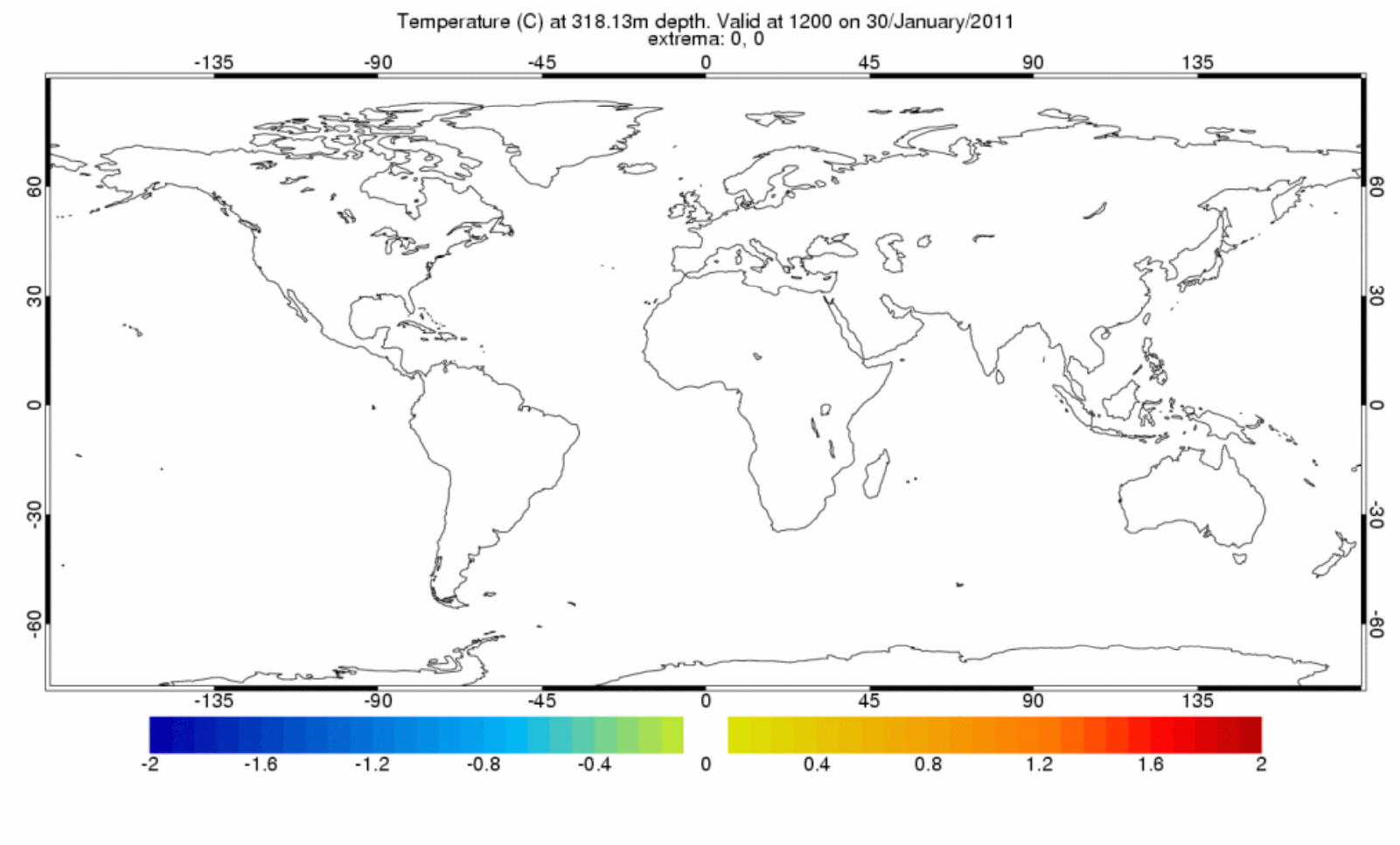
SST



Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

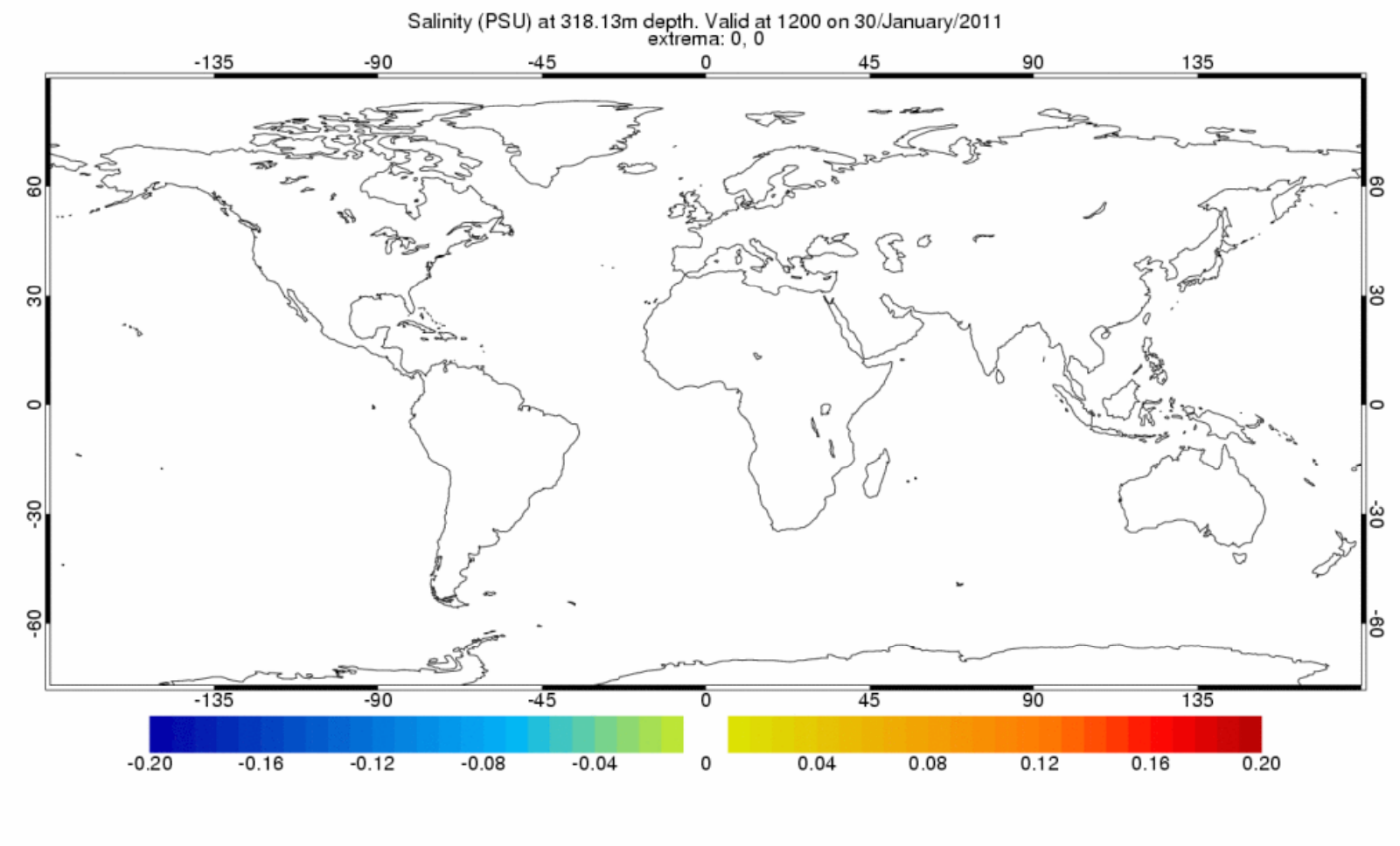
NRT OSEs – with-holding XBT data (February 2011)
Impact on sub-surface temperature (320 m depth)



Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

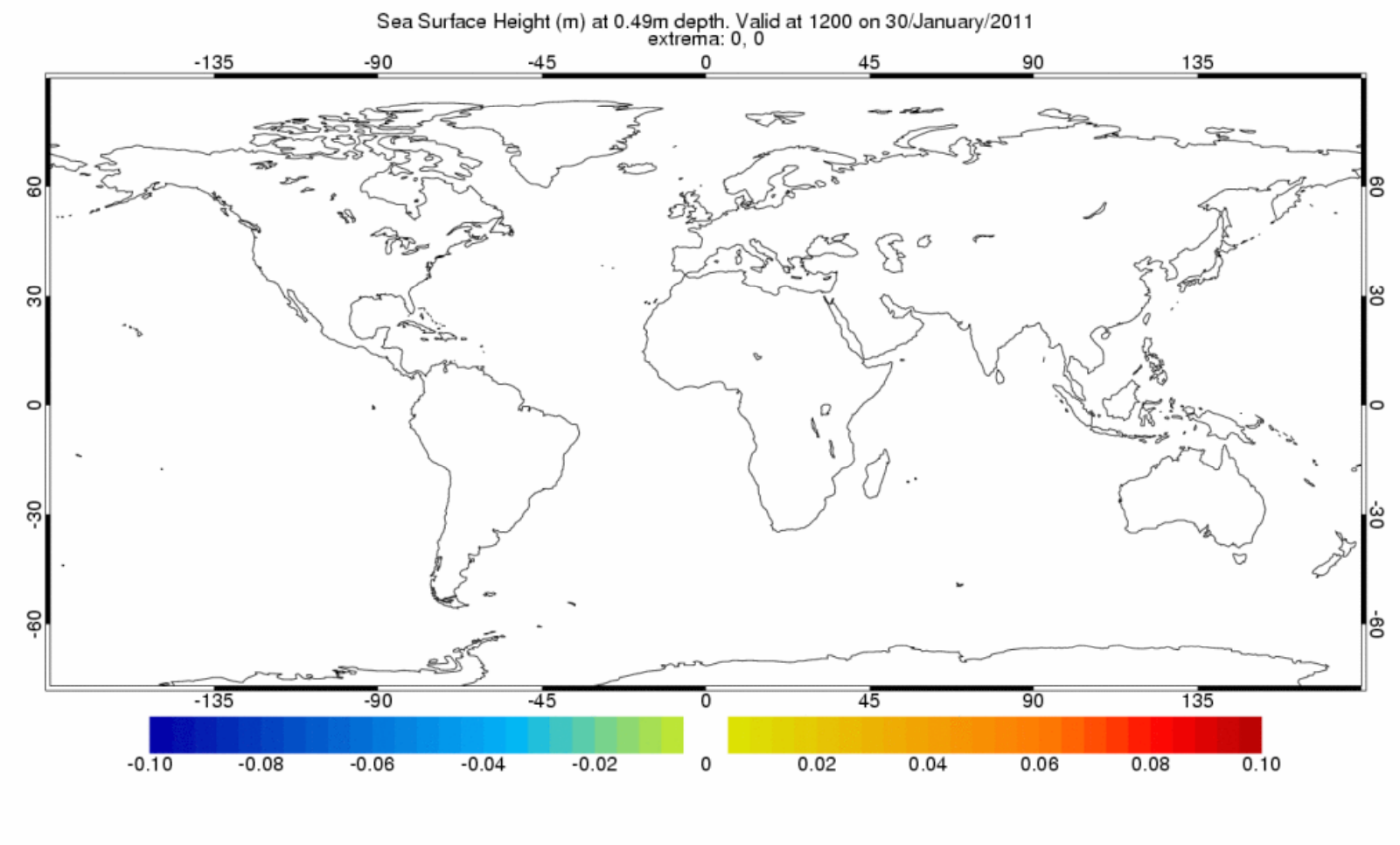
NRT OSEs – with-holding XBT data (February 2011)
Impact on sub-surface salinity (320 m depth)



Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

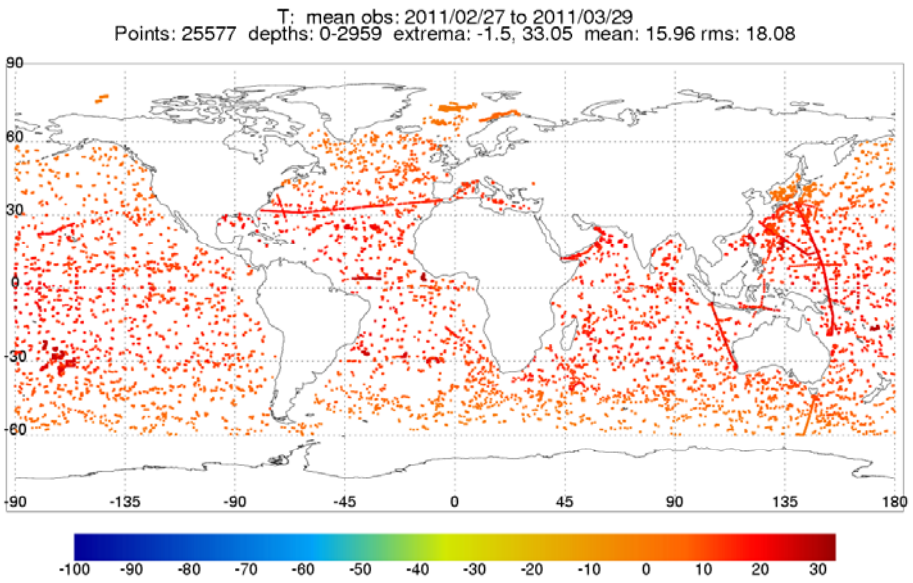
NRT OSEs – with-holding XBT data (February 2011)
Impact on sea surface height

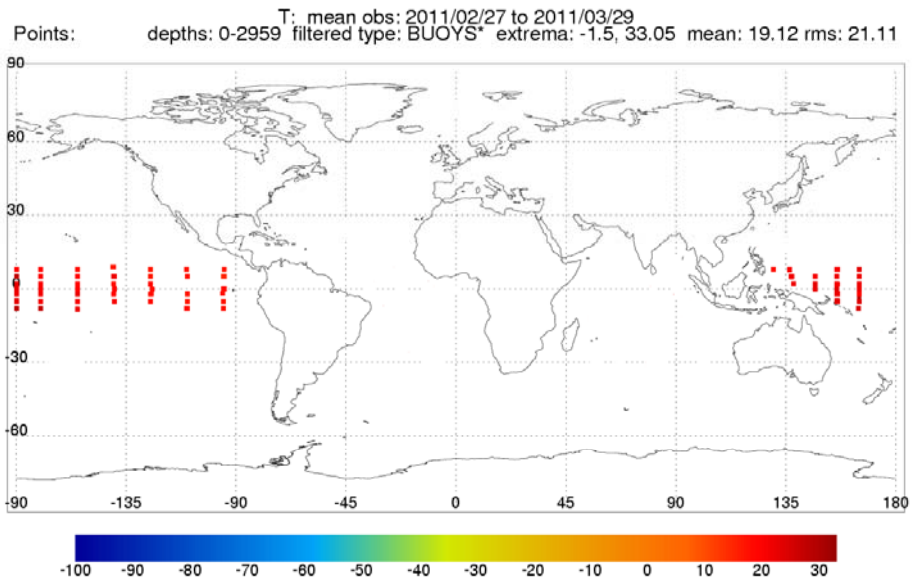


Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

Exclude TAO/TRITON (March 2011)





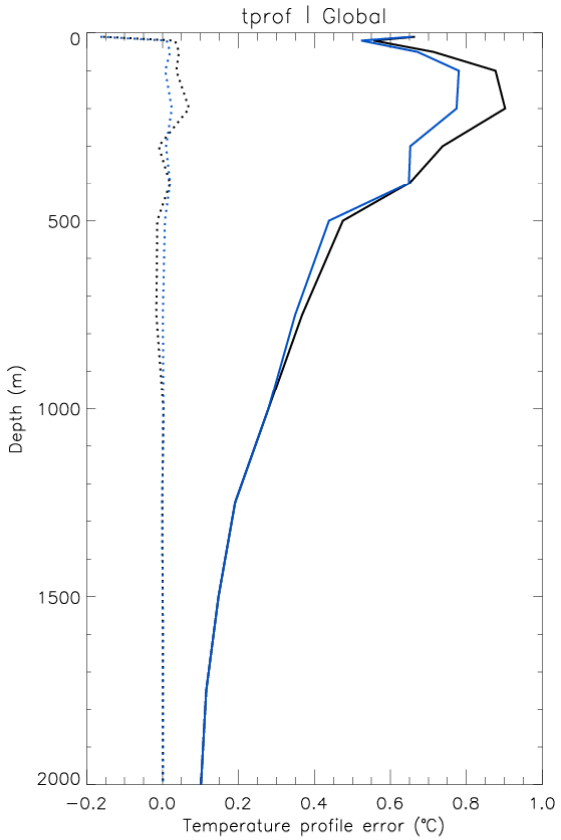
Contributed by D. Lea, UKMet Office

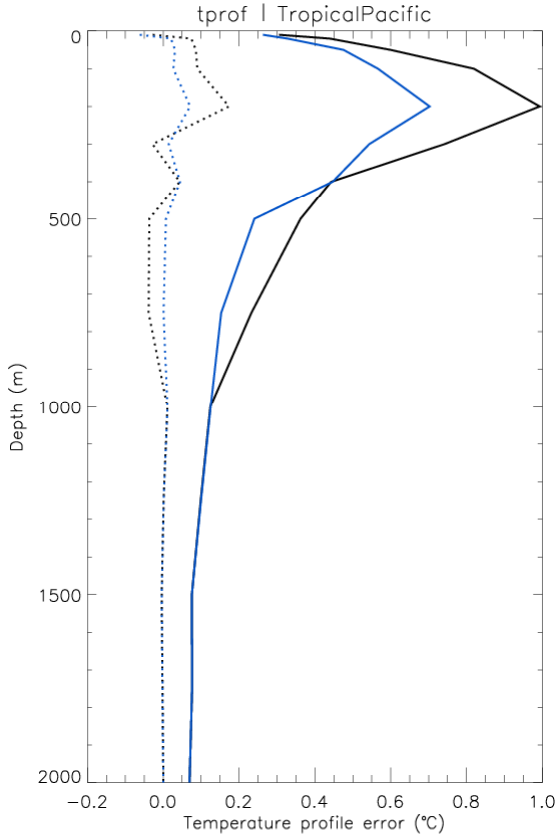
www.cmar.csiro.au/staff/oke/

Exclude TAO/TRITON
Impact on temperature

obs – minus background Mean and RMS

blue operational, black OSE





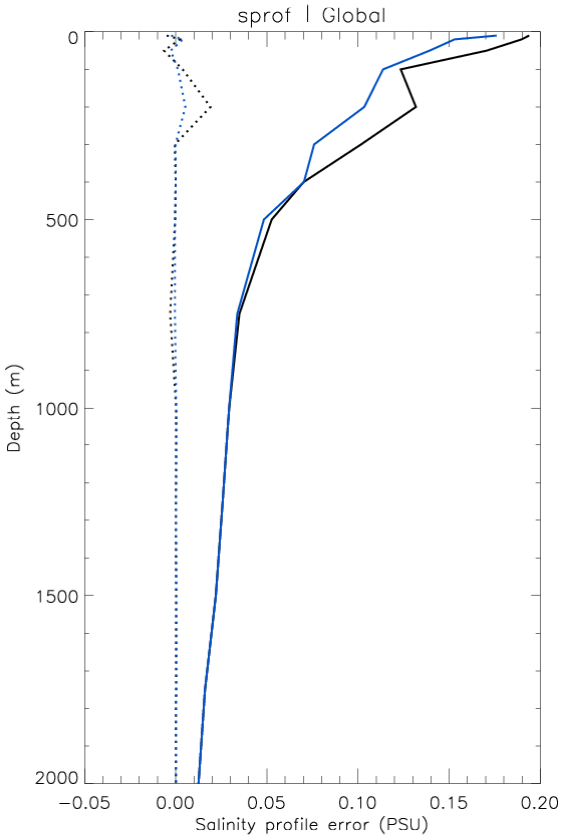
Contributed by D. Lea, UKMet Office

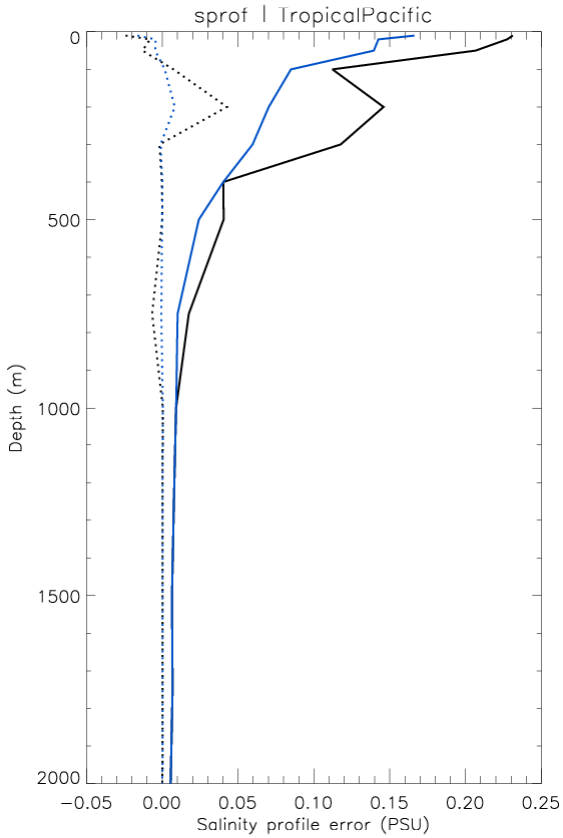
www.cmar.csiro.au/staff/oke/

Exclude TAO/TRITON
Impact on salinity

obs – minus background Mean and RMS

blue operational, black OSE



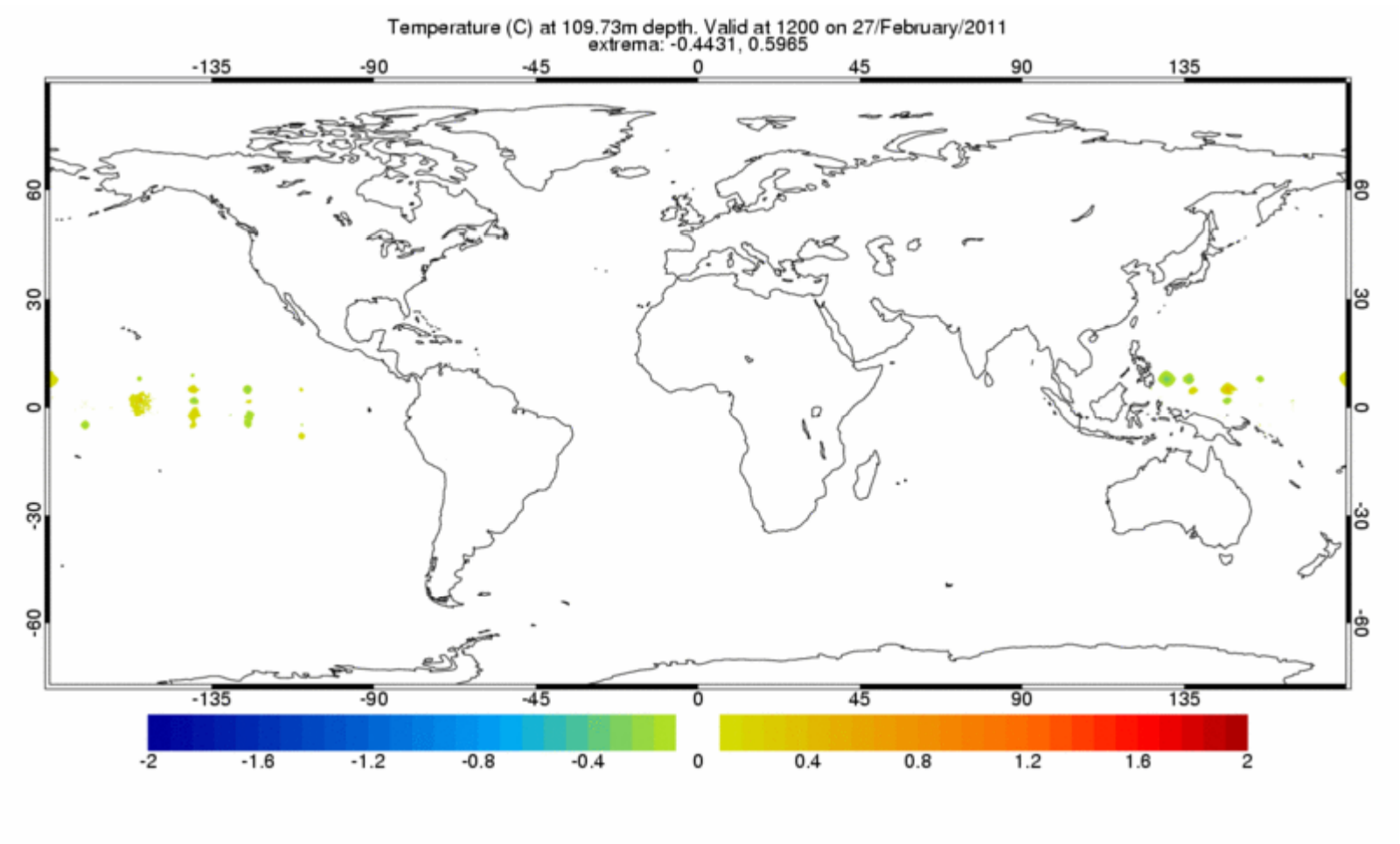


Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

Exclude TAO/TRITON
Impact on T110

Animation

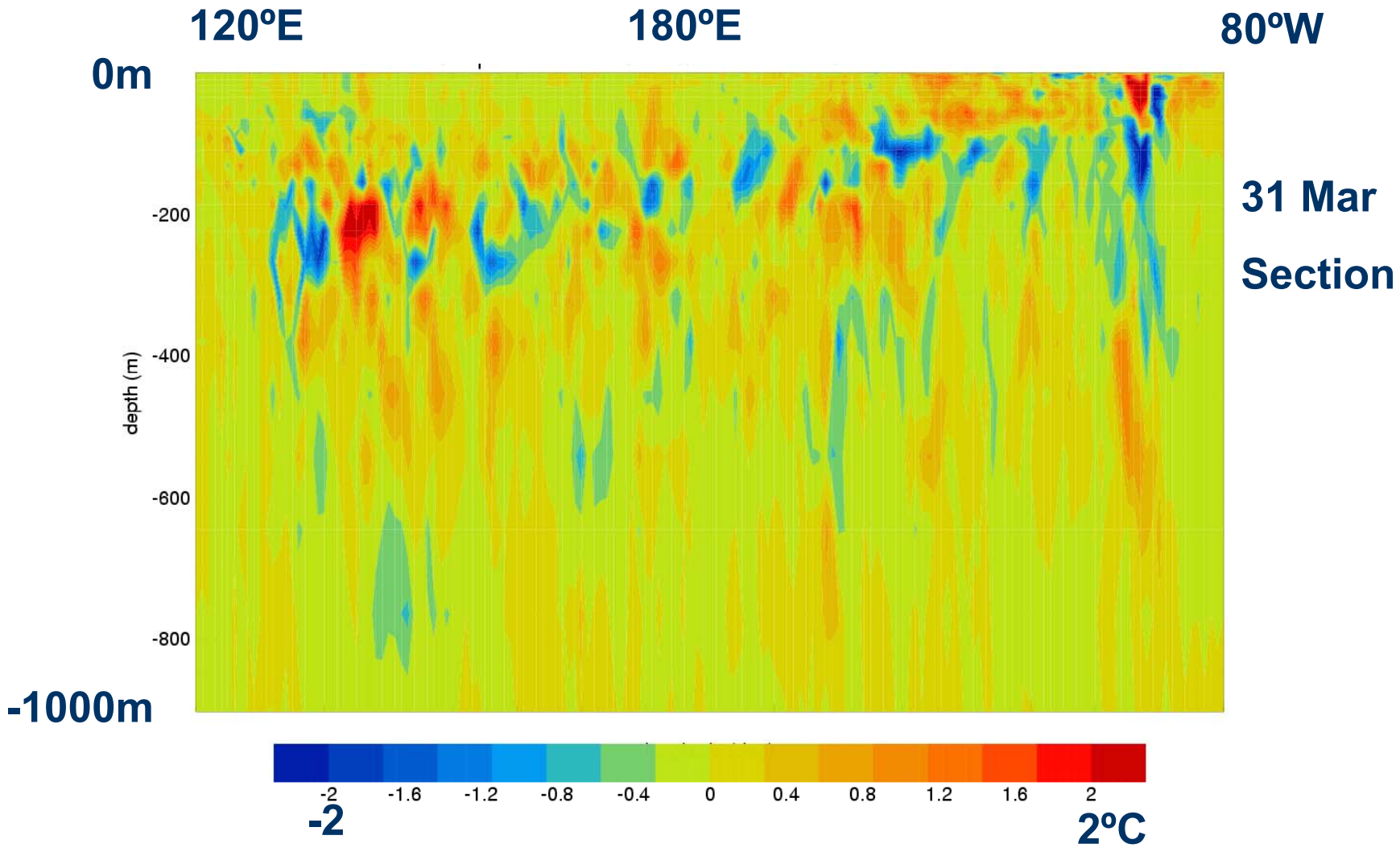


Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

Exclude TAO/TRITON
Impact on sub-surface temperature

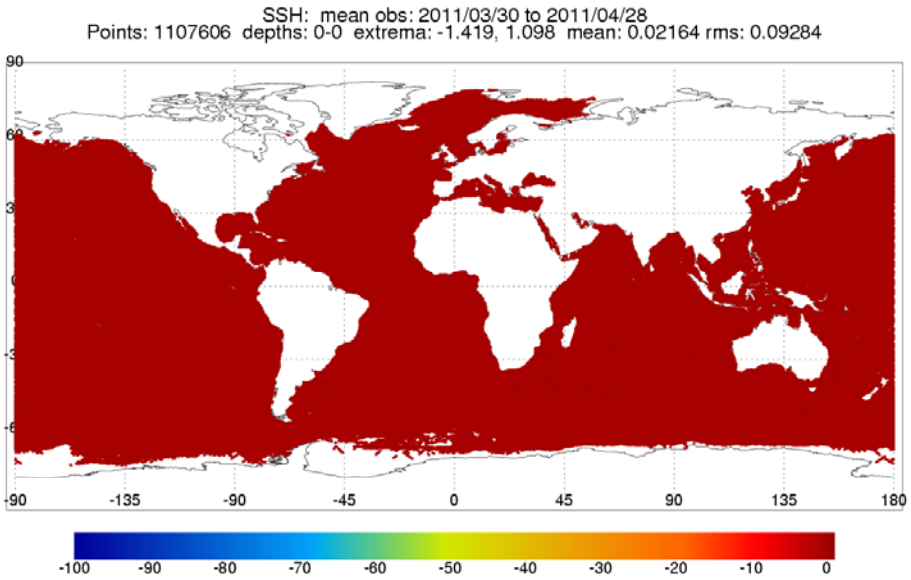
Cross section 30 Mar

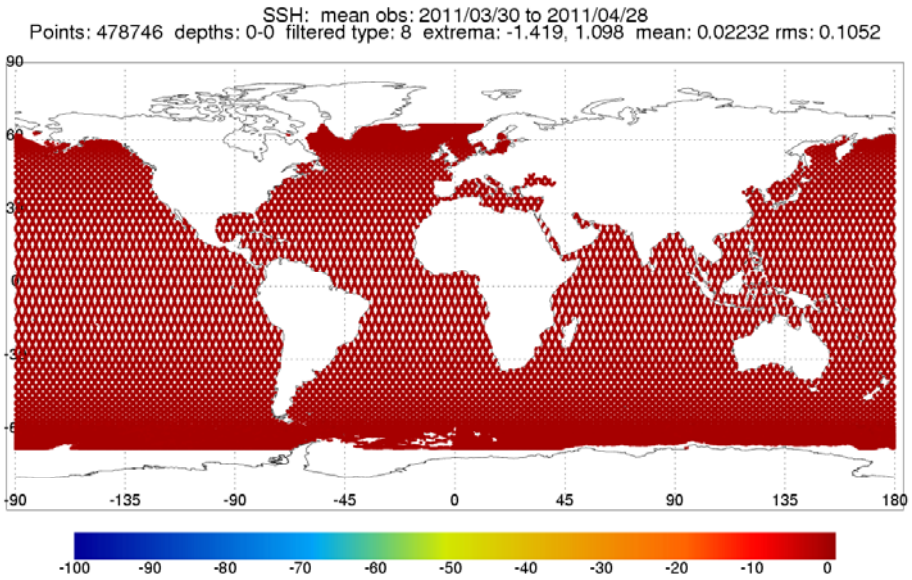


Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

Exclude Jason 2 / All altimeter (Apr / May)





1 month of data

Contributed by D. Lea, UKMet Office

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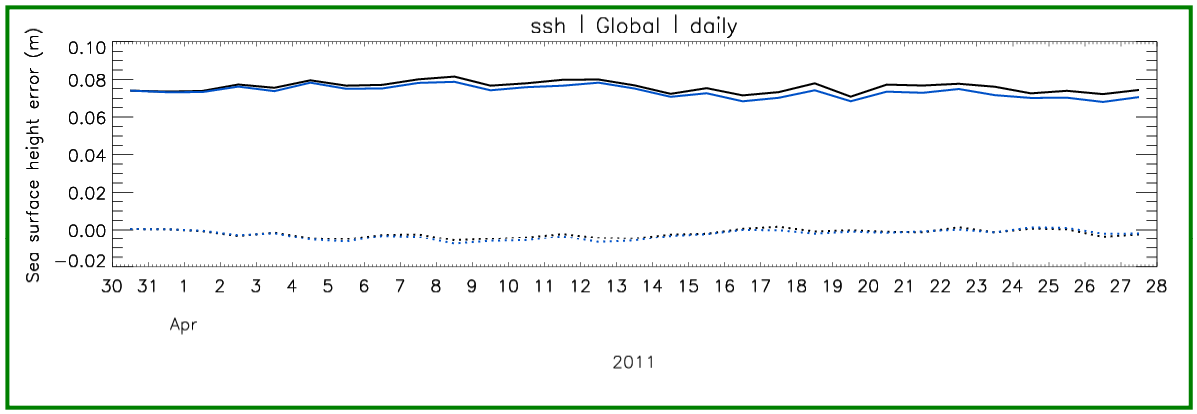
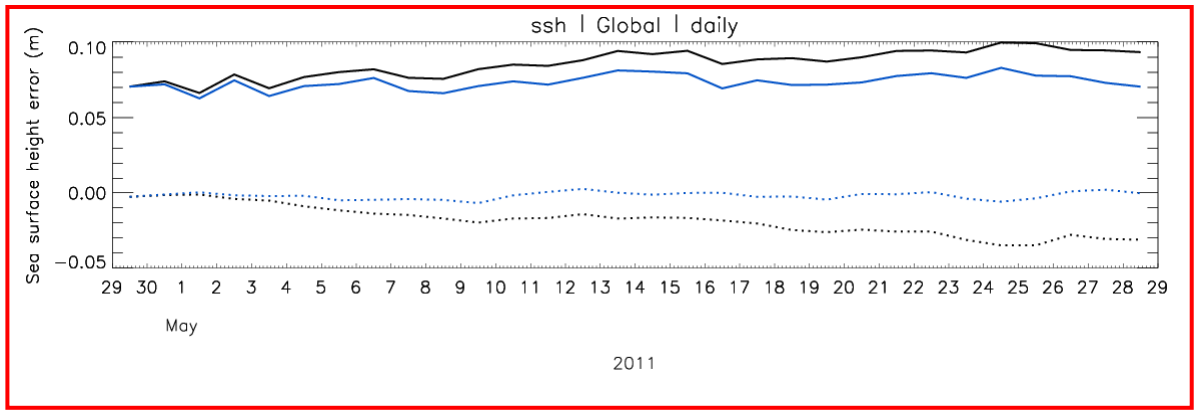
Exclude Jason-2 / All altimeter



***Exclude J-2**

***oper**



***Exclude all altimeter**

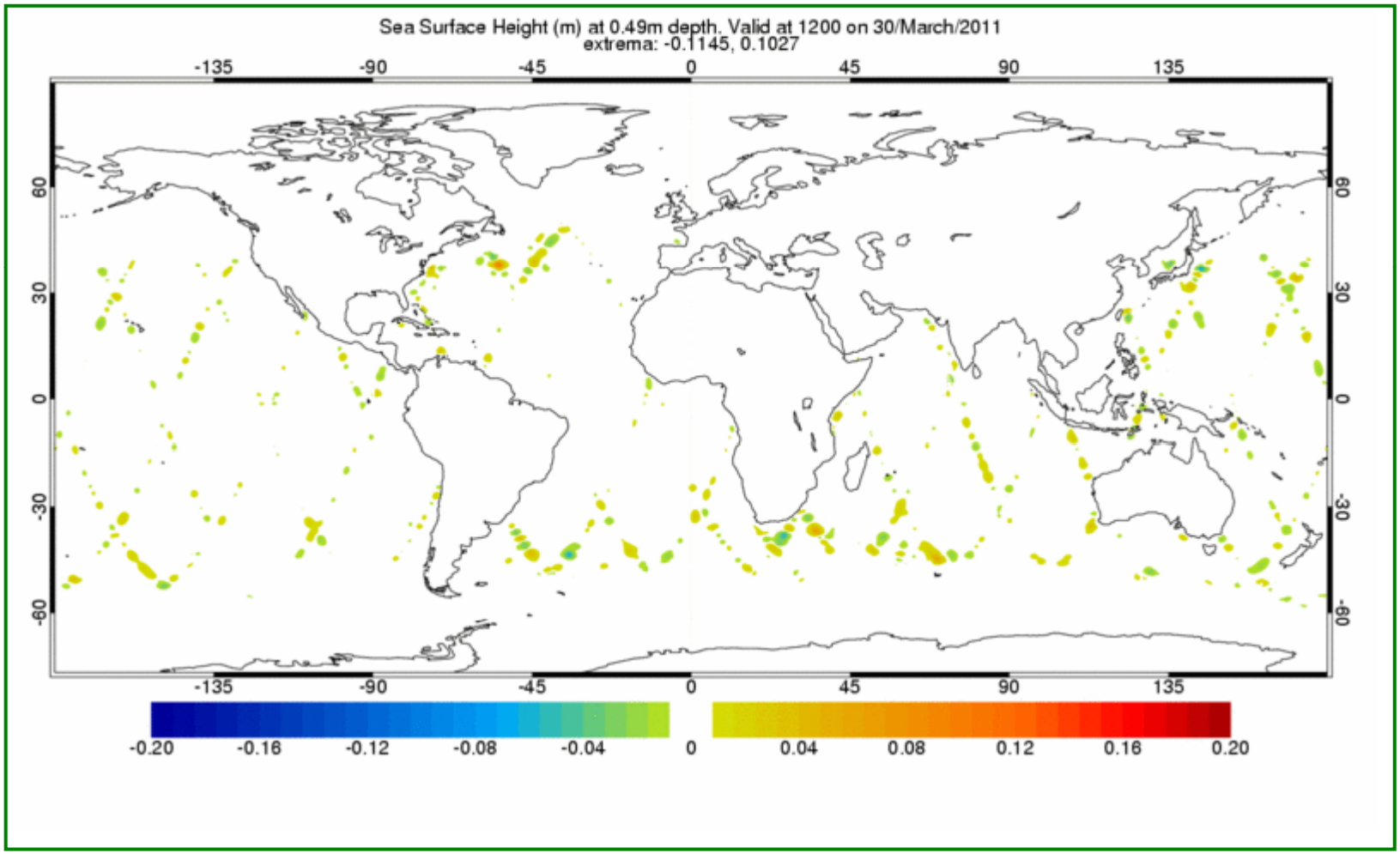
***oper**

Contributed by D. Lea, UKMet Office

www.cmar.csiro.au/staff/oke/

Exclude Jason-2 / All altimeter

Animation for Jason-2 OSE



Contributed by D. Lea, UKMet Office

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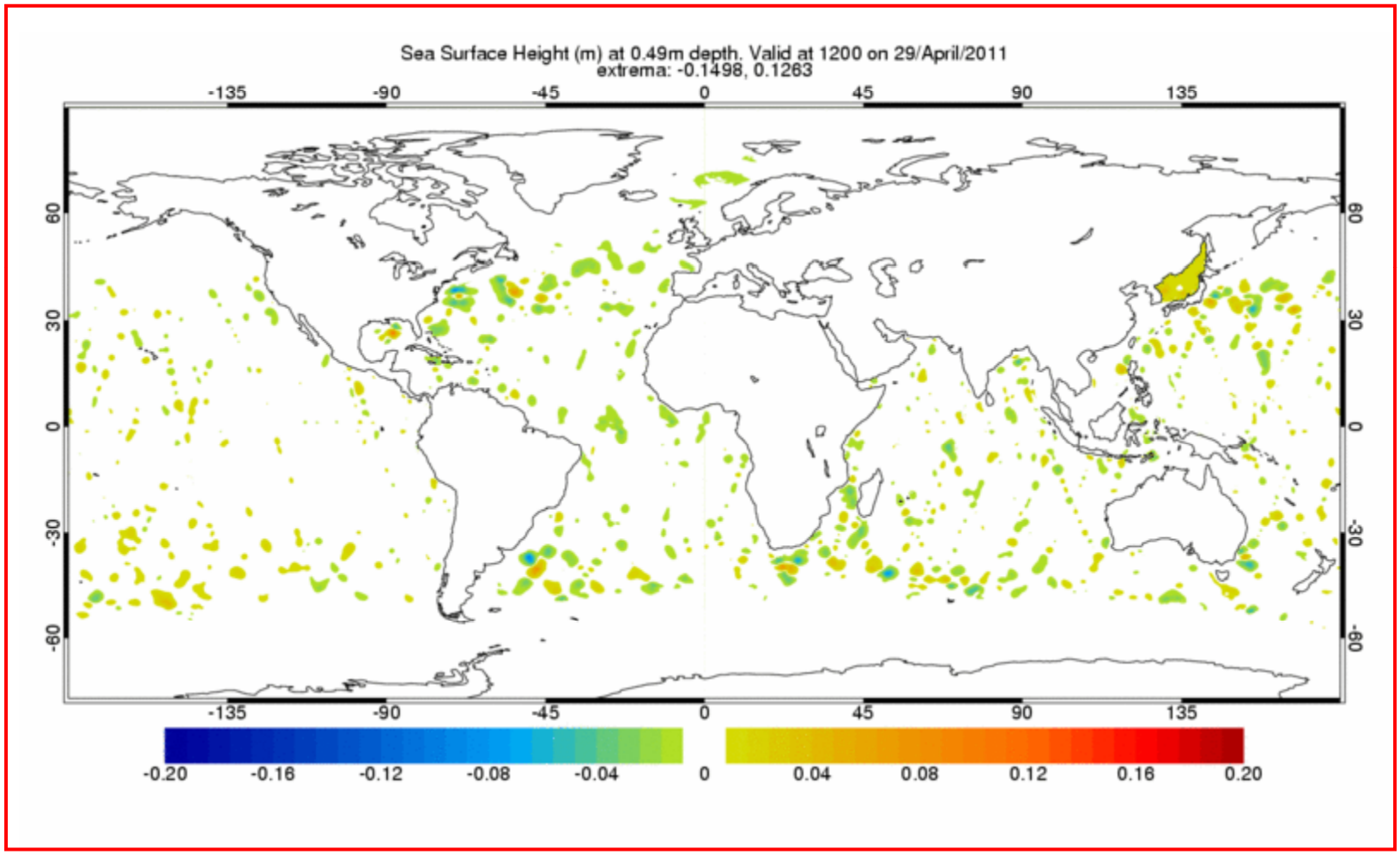
Exclude Jason-2 / All altimeter

Animation for “all altimeter” OSE

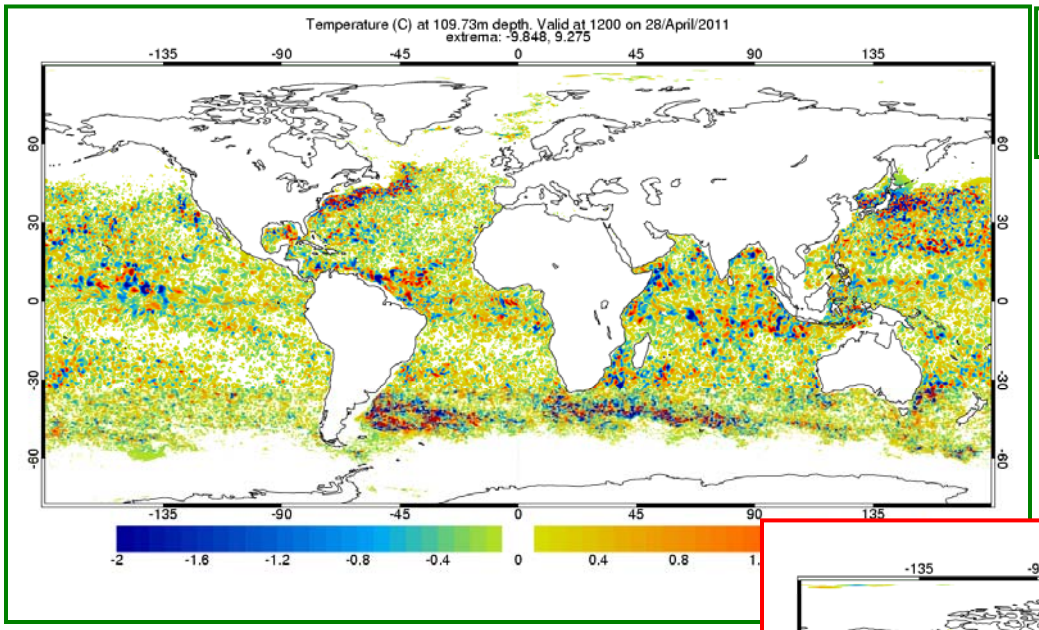


Contributed by D. Lea, UKMet Office

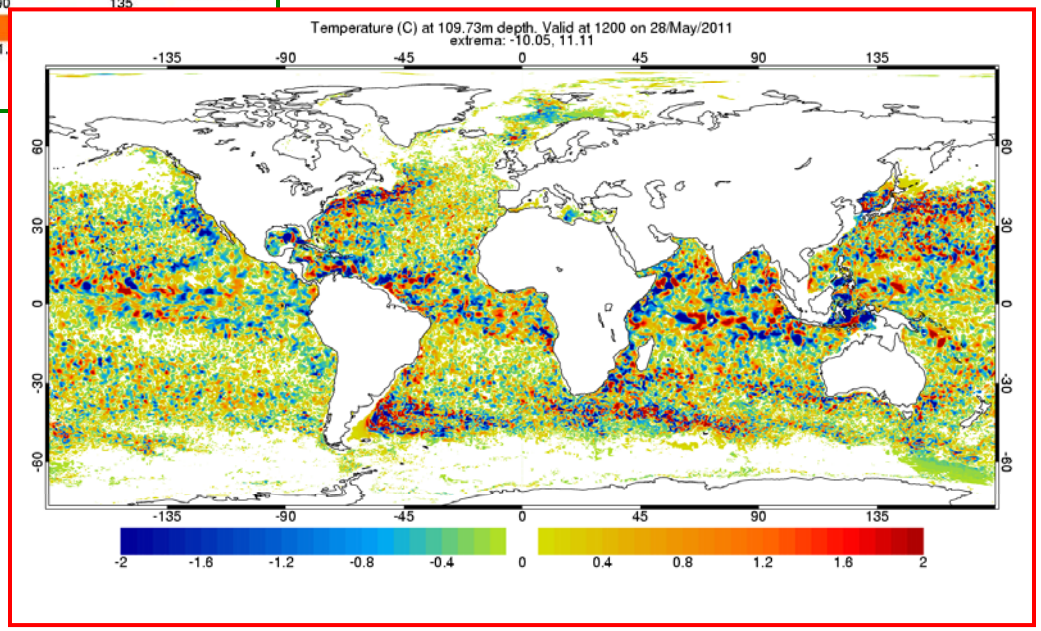
www.cmar.csiro.au/staff/oke/

Exclude Jason-2 / All altimeter

Final T diff at 100m



Oper minus OSE exclude J-2



Oper minus OSE exclude all altimeter

Contributed by D. Lea, UKMet Office

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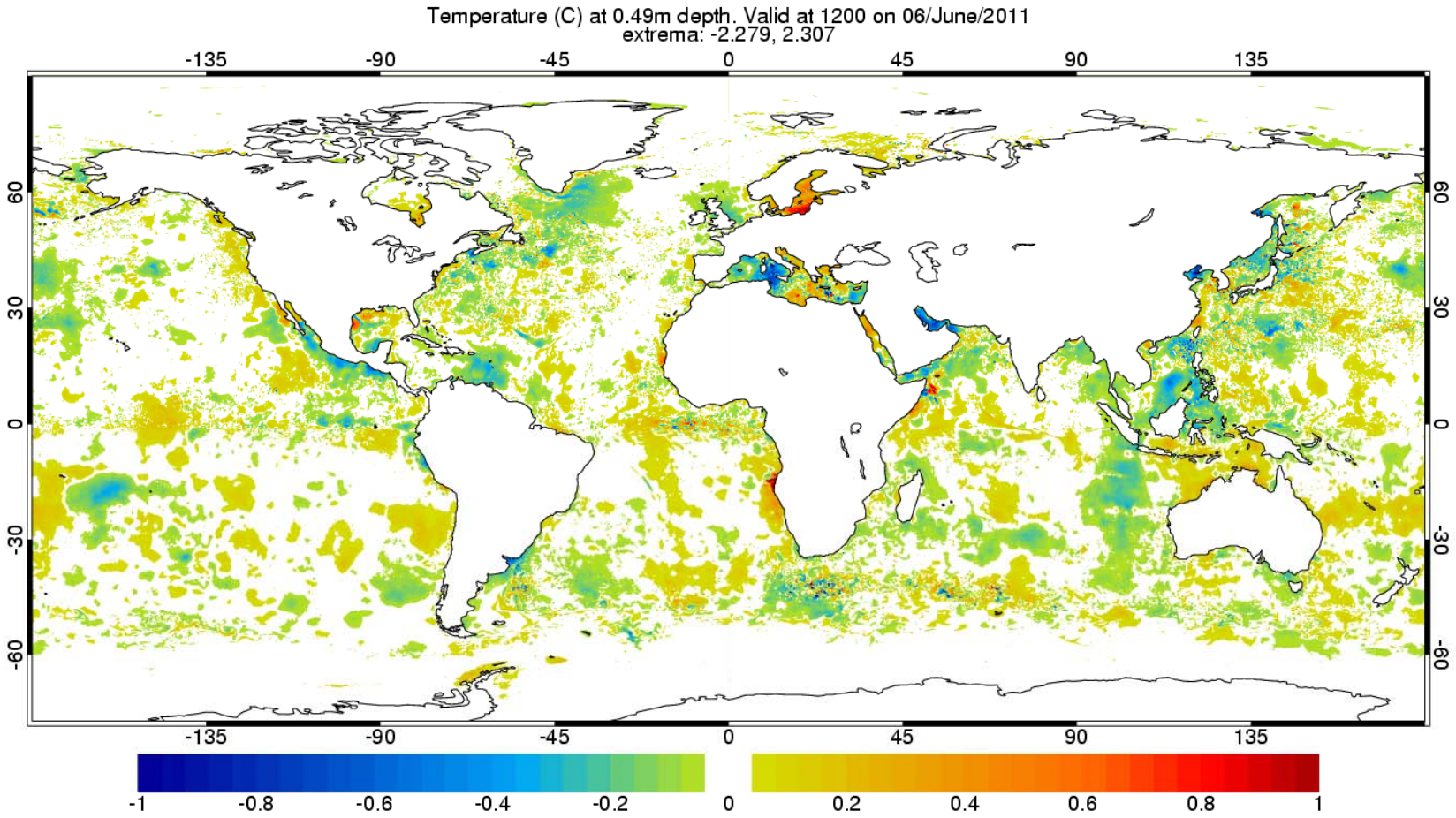
Exclude AVHRR (NOAA&METOP) (Jun)

SST diff



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Summary

- GODAE OceanView OSEval-TT are committed to supporting observation agencies/teams in demonstrating the impact of observations on forecast and analysis products
- Many groups are undertaking research activities to:
  - quantify the impact of past observations; and
  - contribute to the design of future observing systems
- Recent initiatives have motivated operational centers to develop capabilities for quantifying the impact of current observations in NRT
- The OSEval-TT are developing the idea of “Observation Impact Statements” … p*lease help us figure out how to do this*

Summary – relating specifically to XBT

- XBT data are assimilated by all operational centers associated with GODAE and GODAE OceanView:
  - XBT is a core data set for short-range forecasting
- Assimilation of in situ observations improves seasonal predictions by up to 25% for some key variables
- Assimilation of XBT data in the Gulf of Mexico after the DWH oil spill reduced forecast errors by up to 1/3rd of the signal
- Assimilation of XBT data using the UKMet short-range forecast system (FOAM) reduces forecast errors by:
  - over 2 degrees for sub-surface temperature;
  - over 0.2 psu for salinity; and
  - over 10 cm for sea-level

  … in the vicinity of the XBT lines during the February 2011 GODAE OceanView NRT OSE