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# **Cryosat-2 SAR altimetry processing and use in the Arctic Ocean**

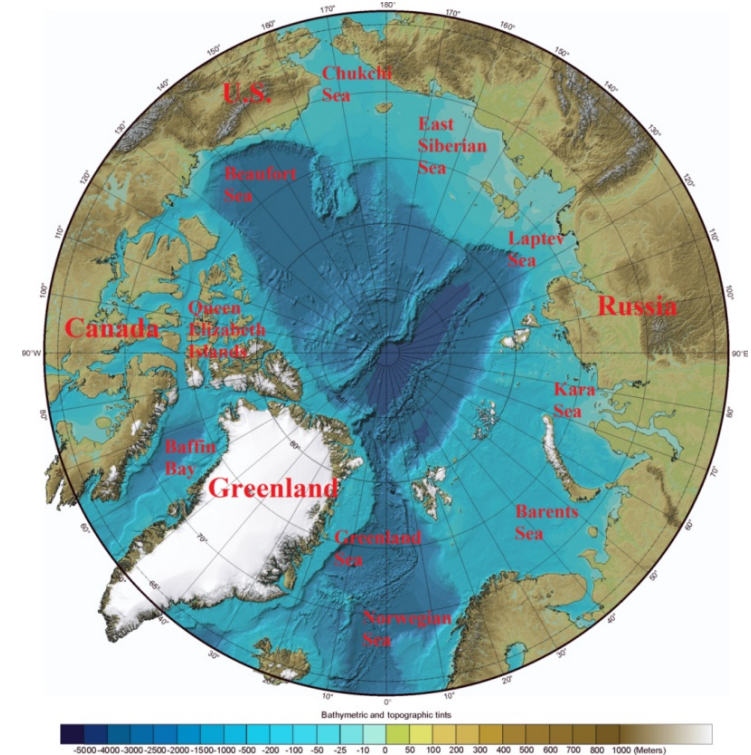
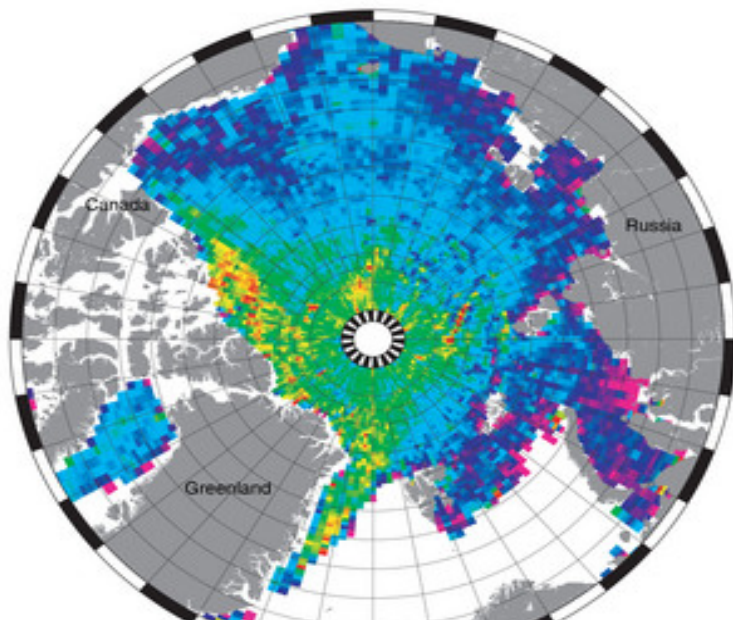
Ole Andersen , M. Jain & Lars Stenseng

# Context

We investigate satellite altimetry in the Arctic Ocean for

- 1) Studies of long term changes
- 2) Mean sea surface determination.
- 3) MDT determination with GOCE
- 4) Ocean circulation.
- 5) Ocean tide modelling

Sea ice thickness in the Arctic ocean  
(January/February 2011)



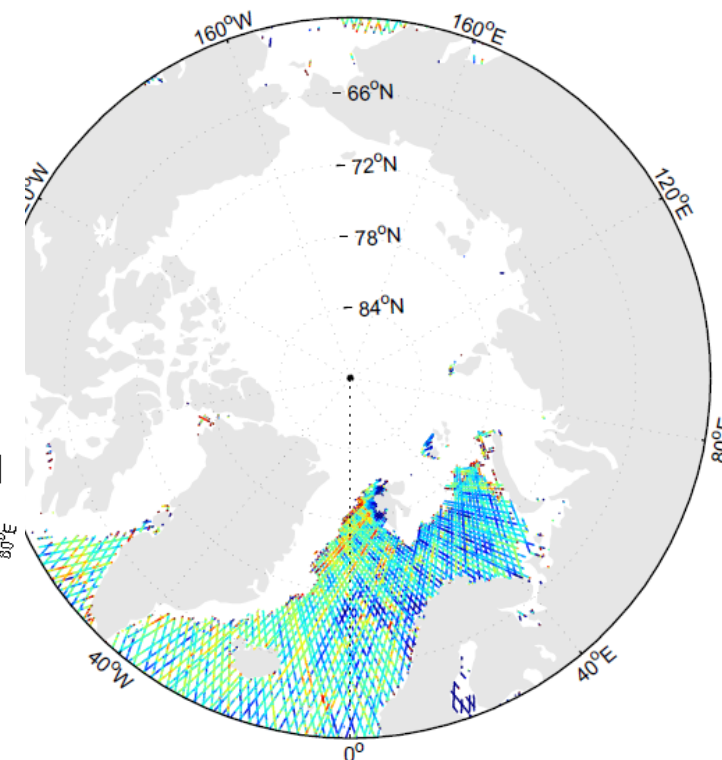
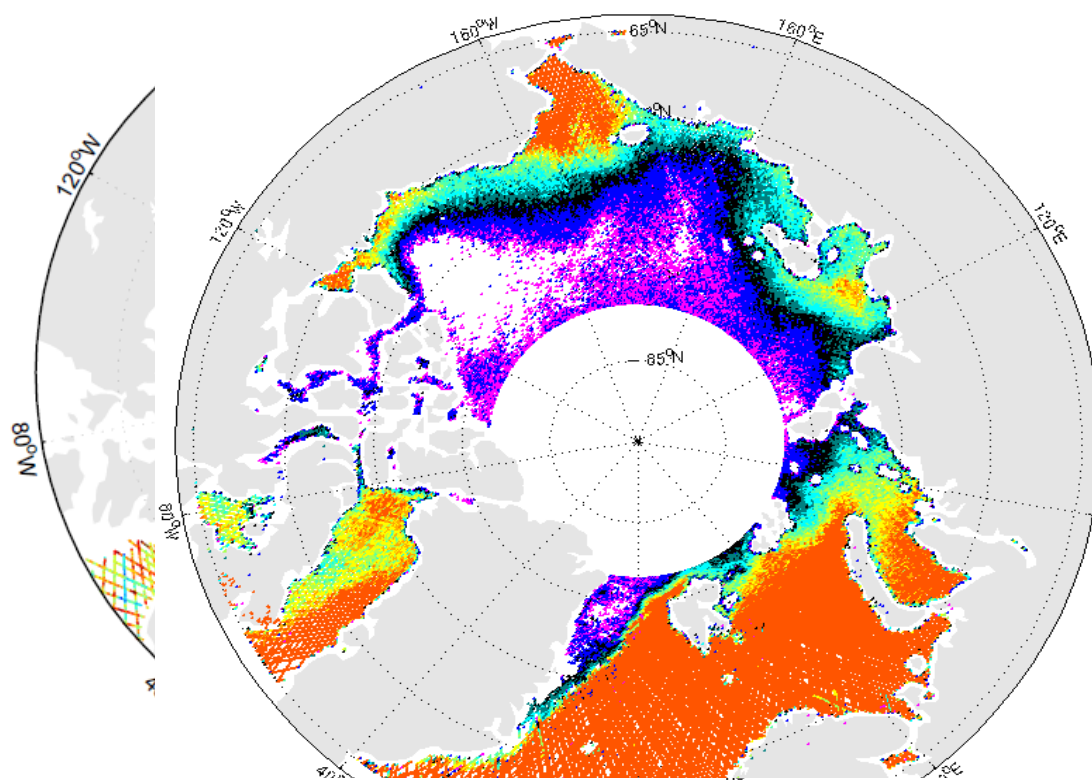
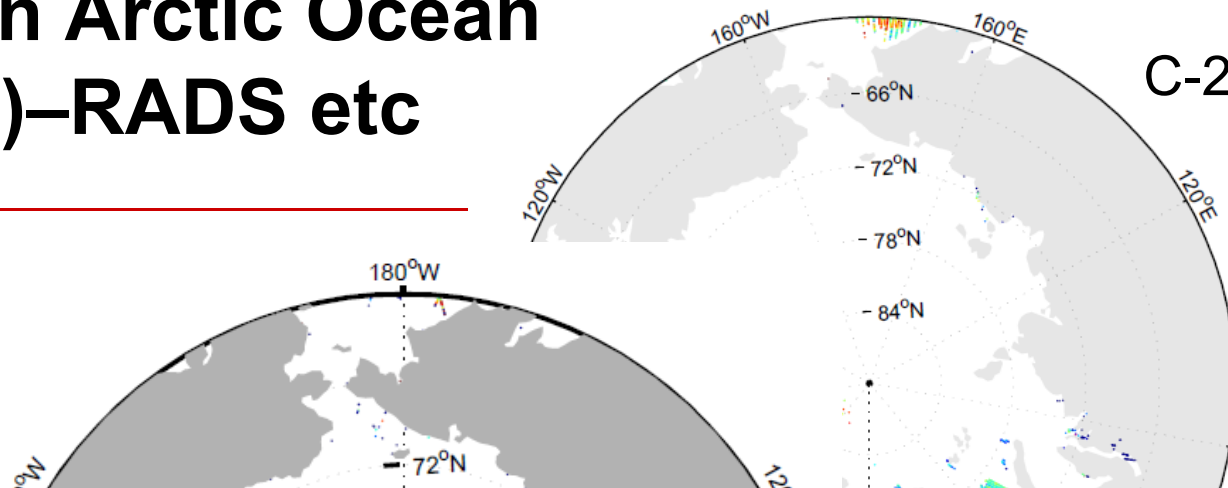
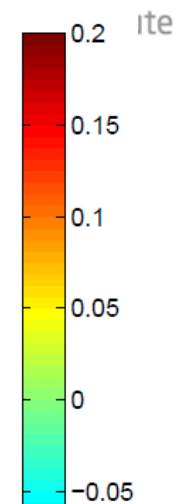
Large portion covered by sea ice  
Large variation in surface types



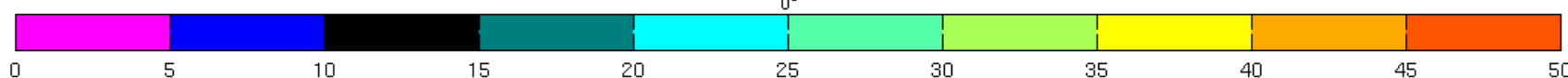
# 1 Hz Data in Arctic Ocean (April 2013)–RADS etc

DTU Space

C-2



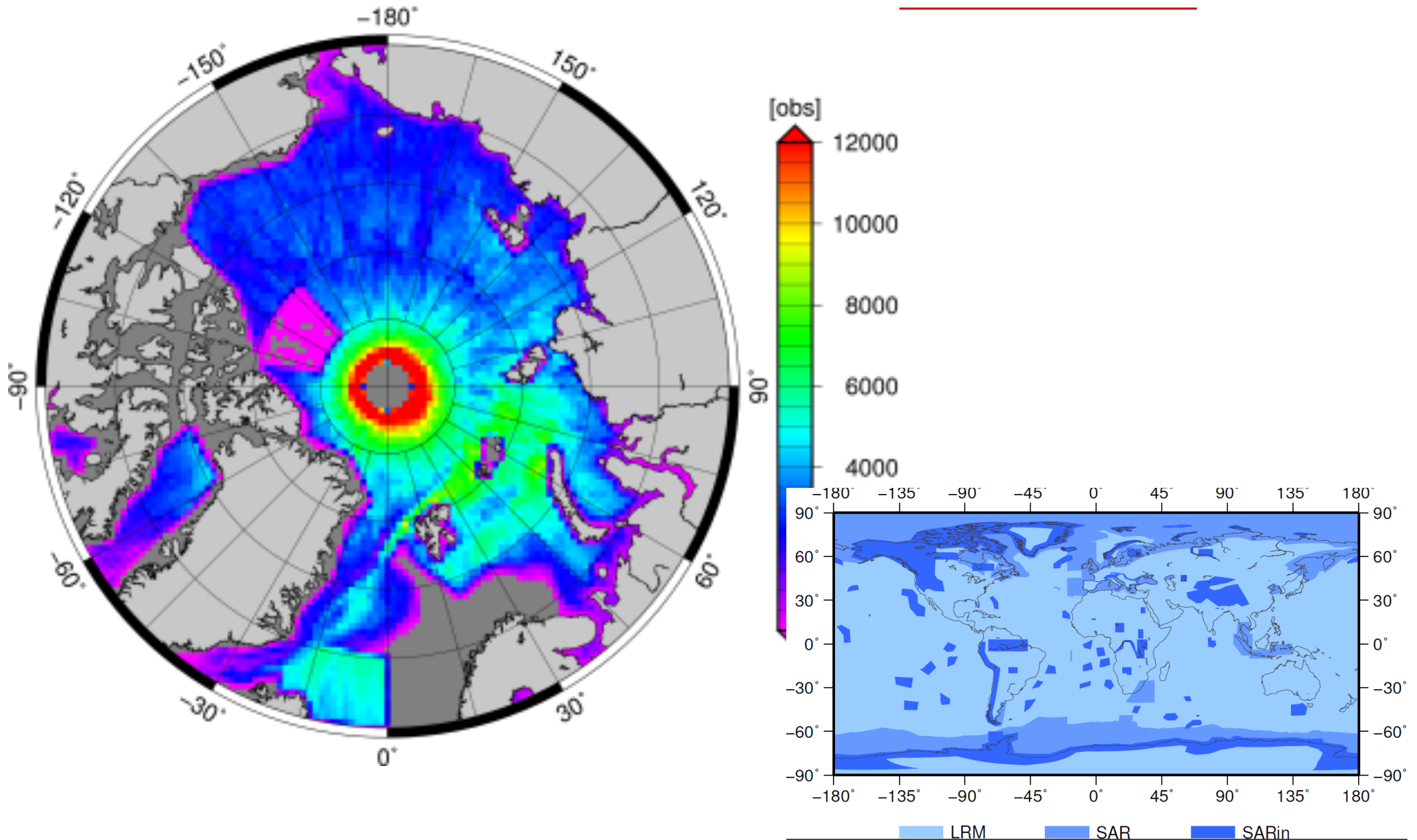
2 days)



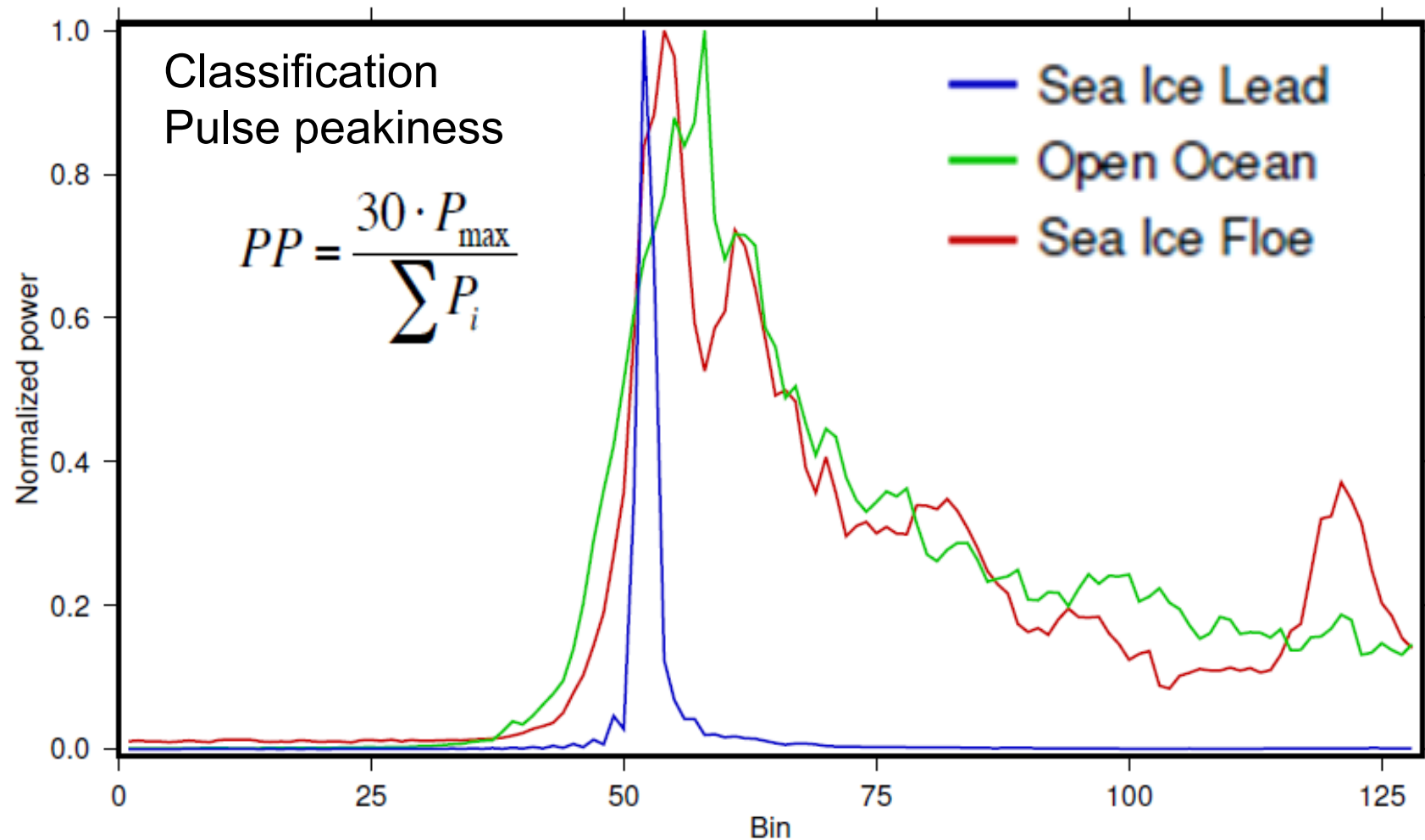
**AltiKa**  
Group Meeting  
, UK, July 2013

# Cryosat-2 20 Hz SAR L1B satellite altimetry (2012)

L2 observations



# Large variation in surface/waveform types

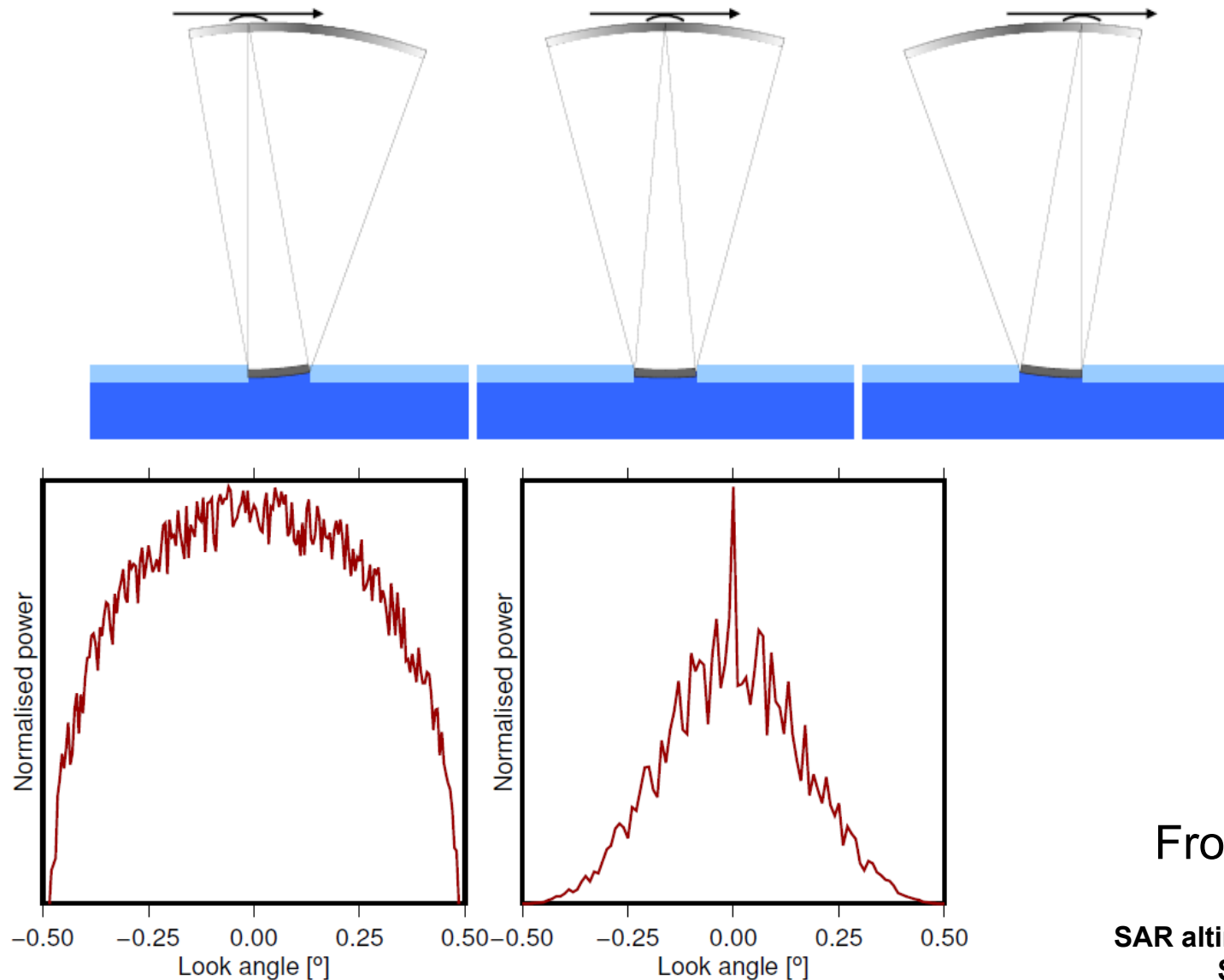


From Laxon and Rapley (1987)

SAR altimetry expert Group Meeting  
Southampton, UK, July 2013



# Classification: Stack Standard Deviation

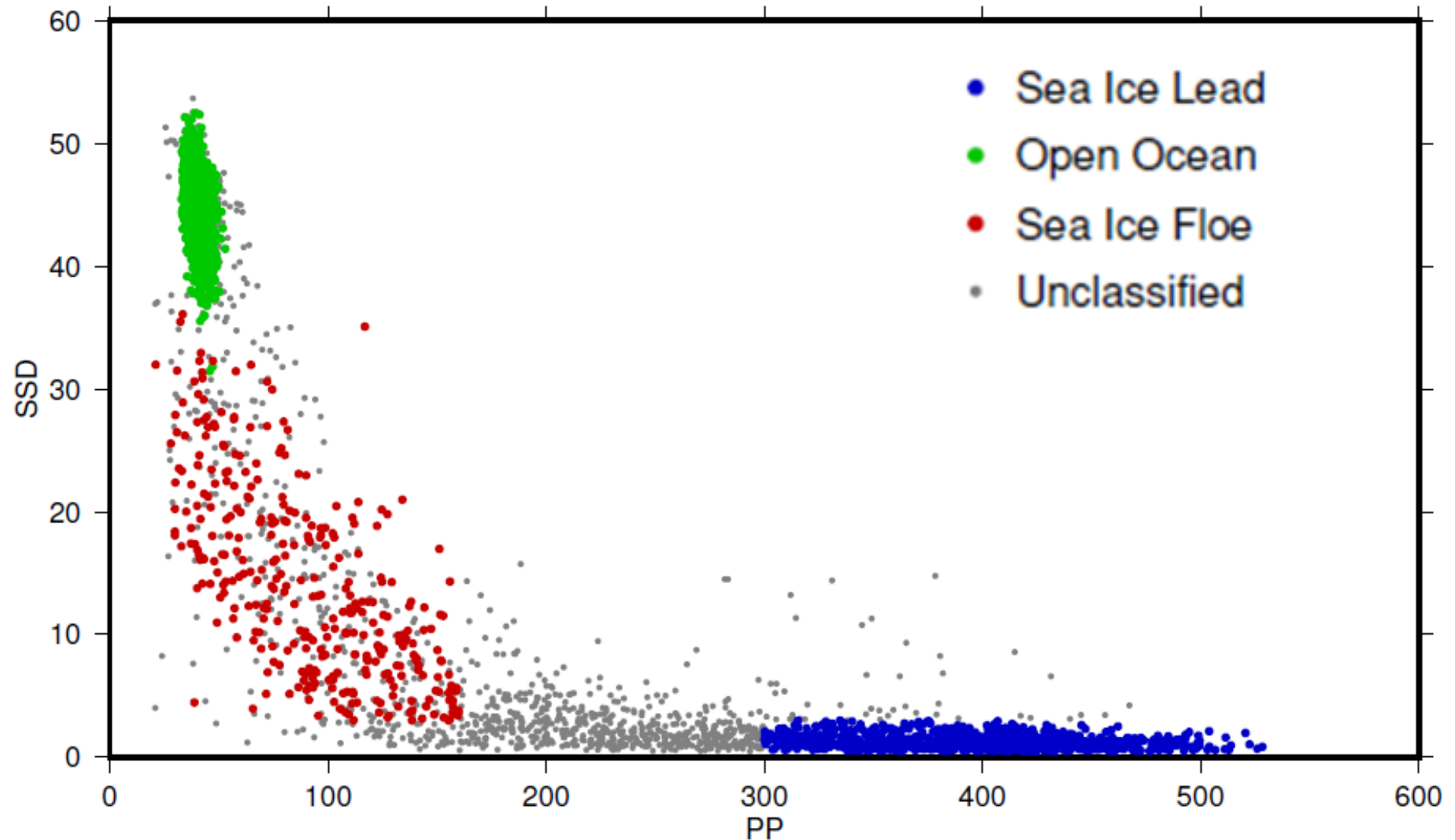


From Wingham(2006)



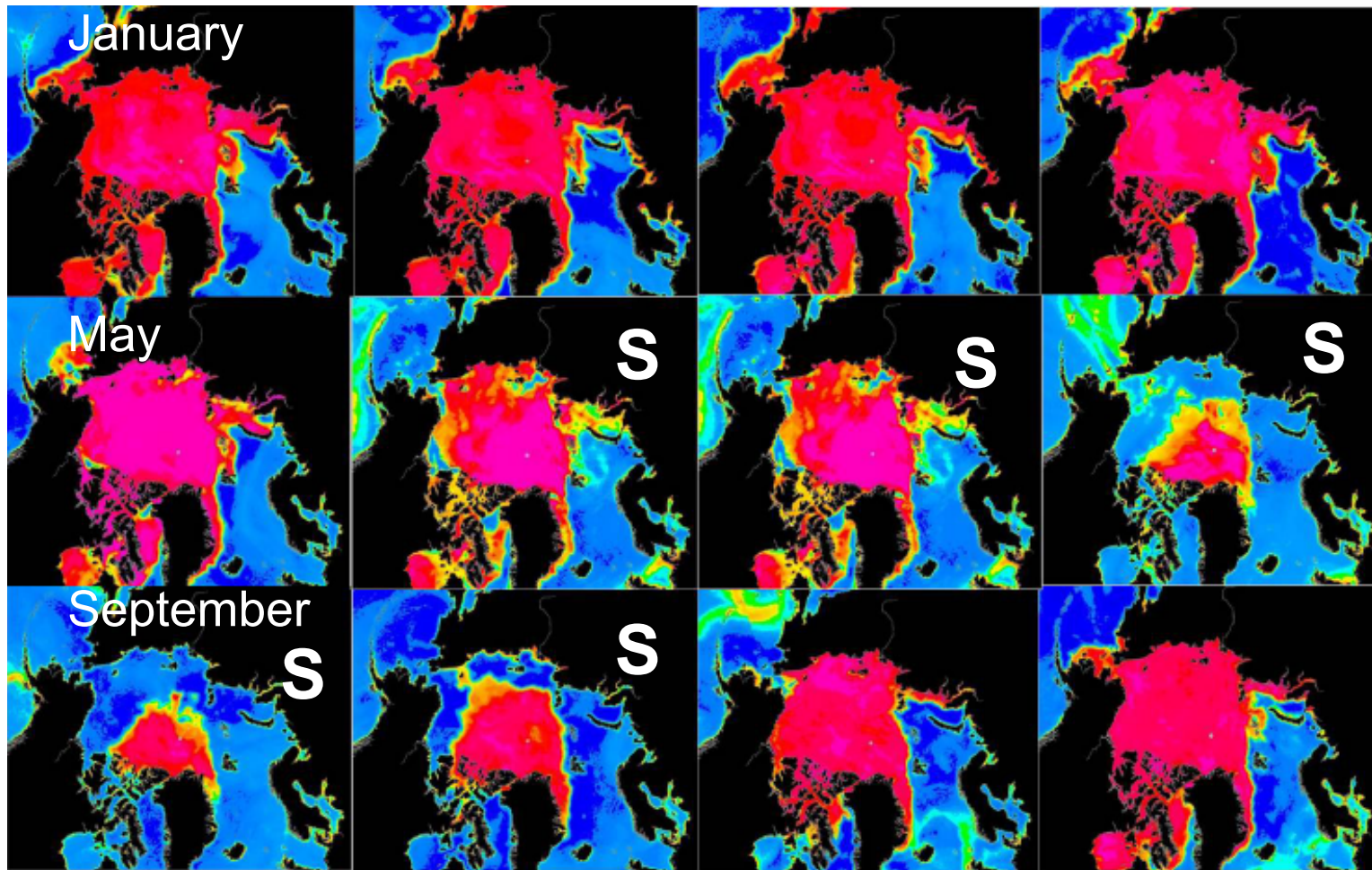
# Arctic Cryosat-2 Classification

## Stack Standard Deviation vs Pulse Peakiness



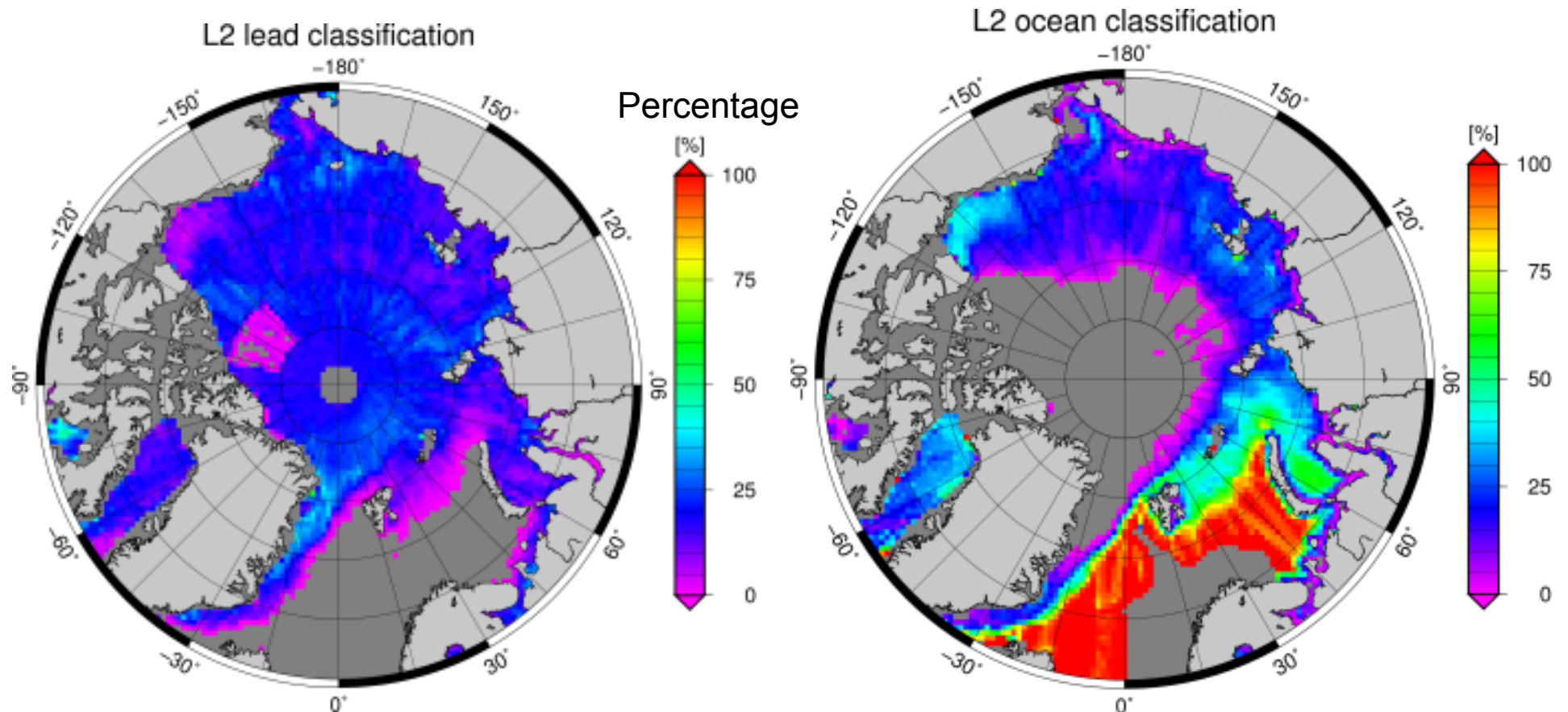
# Lead/Ocean classification

## Summer vs Winter





# Cryosat-2 SAR satellite altimetry for 2012



# Applying 6 SAR Empirical Retracker

"Simple and rough retracker"

R1 - Traditional OCOG Rtrk

R2 - Traditional Threshold Rtrk

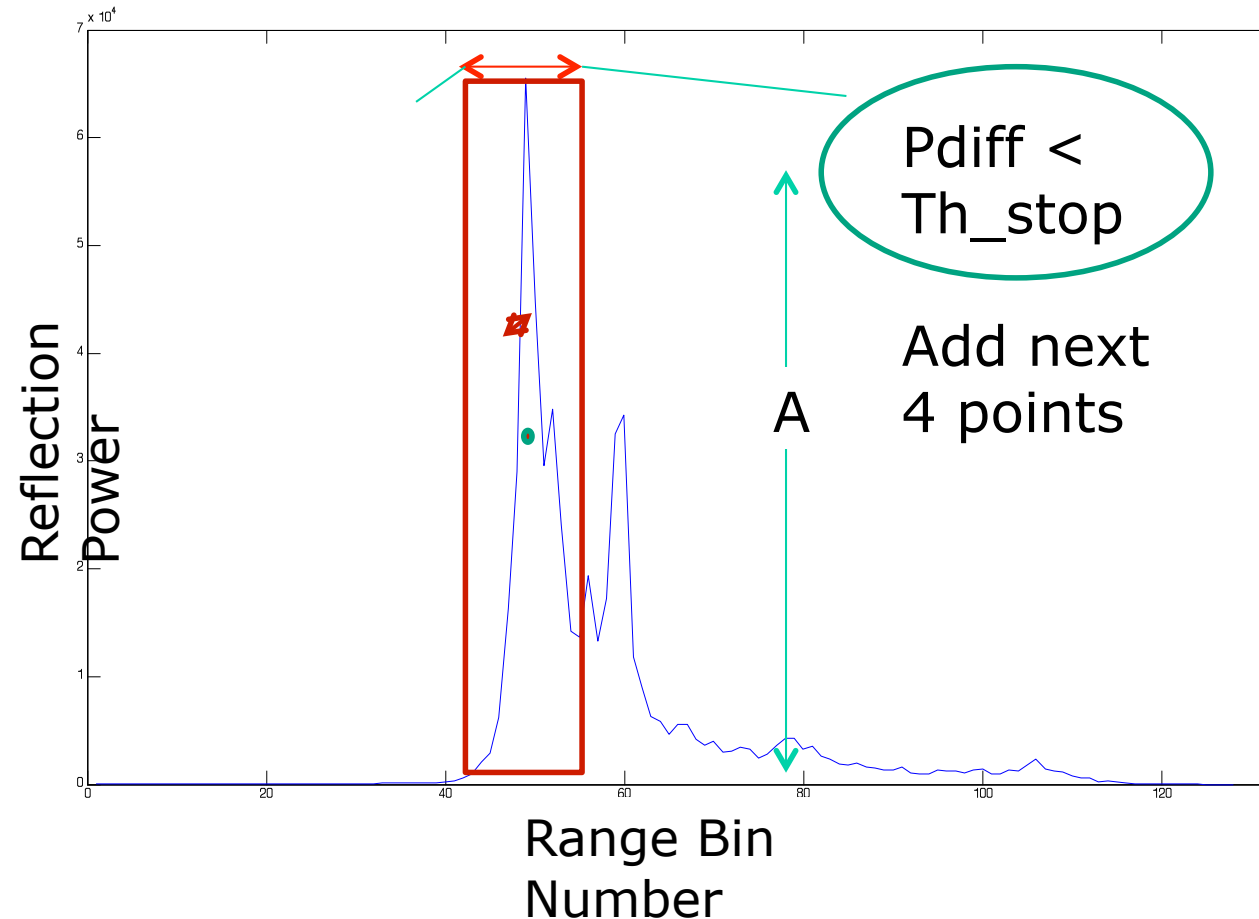
R3 - Five parameter Beta Rtrk

R4 - Primary Peak OCOG Rtrk

R5 - Primary Peak Threshold Rtrk

R6 - ESA Retracker

R7 - Simple Threshold Retracking

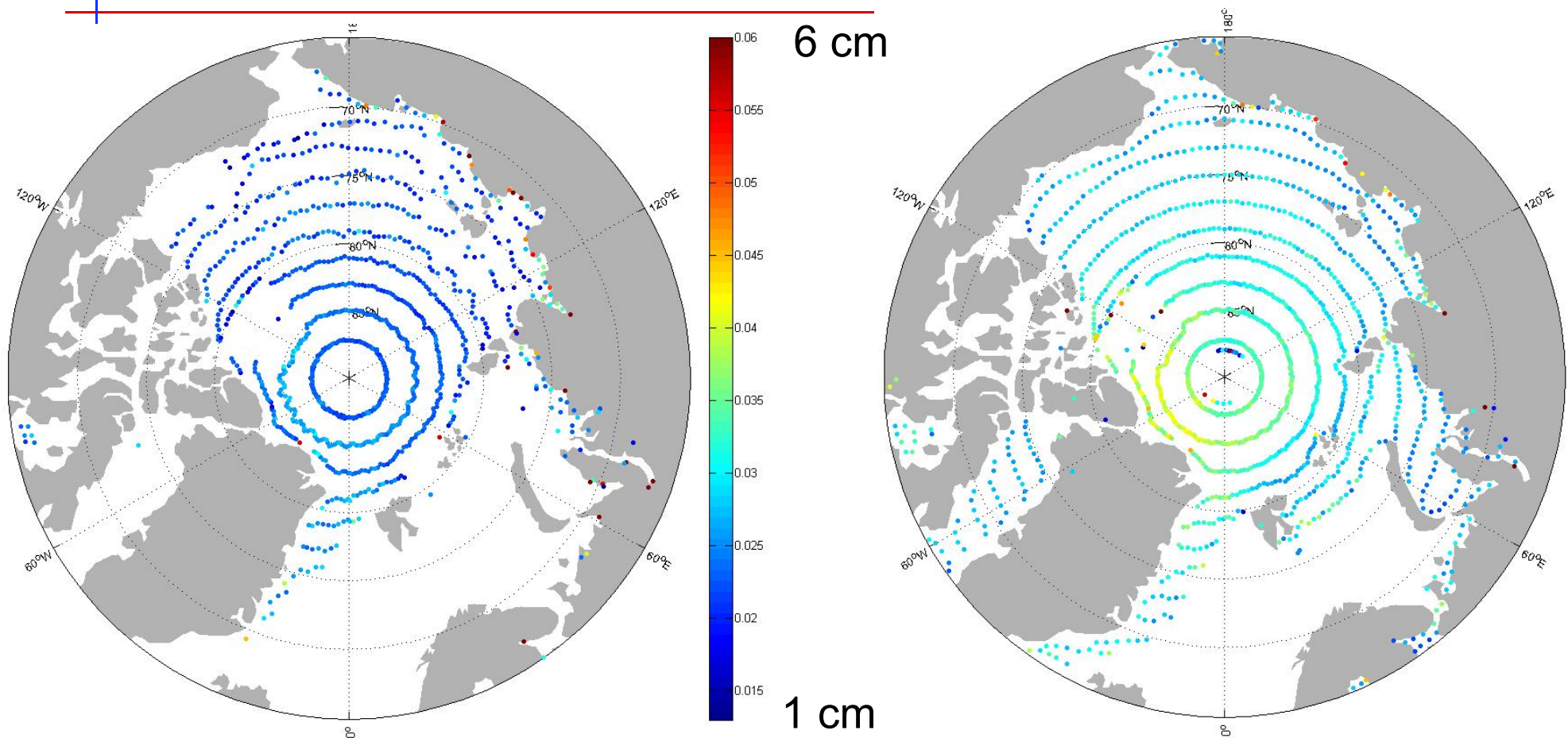


# 1-Hz Std deviation

Retracker	LEAD	Lead - Winter	Lead - Summer
All values in cm			
R1 : Traditional OCOG Retracker		3.02 (442950)	2.33 (160905) ←
R2 : Traditional Threshold Retracker		3.25 (439421)	2.63 (159527)
R3 : 5 parameter Beta Retracker		9.25 (452956)	9.14 (163059)
R4 : primary peak OCOG Retracker		2.95 (444133)	2.28 (161177) ←
R5 : primary peak Threshold Retracker		2.99 (438560)	2.33 (159062) ←
R6 : ESA Retracker (Cryosat-2 Level-2 Product)		3.24 (437469)	2.58 (158853)
Retracker	OCEAN	Ocean - Winter	Ocean - Summer
All values in cm			
R1 : Traditional OCOG Retracker		12.93 (169756)	12.55 (146673)
R2 : Traditional Threshold Retracker		8.4 (173604)	6.9 (152321) ←
R3 : 5 parameter Beta Retracker		11.21 (173504)	9.97 (152399)
R4 : primary peak OCOG Retracker		7.69 (165827)	6.09 (153391) ←
R5 : primary peak Threshold Retracker		8.67 (166798)	7.11 (153653) ←
R6 : ESA Retracker (Cryosat-2 Level-2 Product)		10.96 (168275)	9.18 (148749)

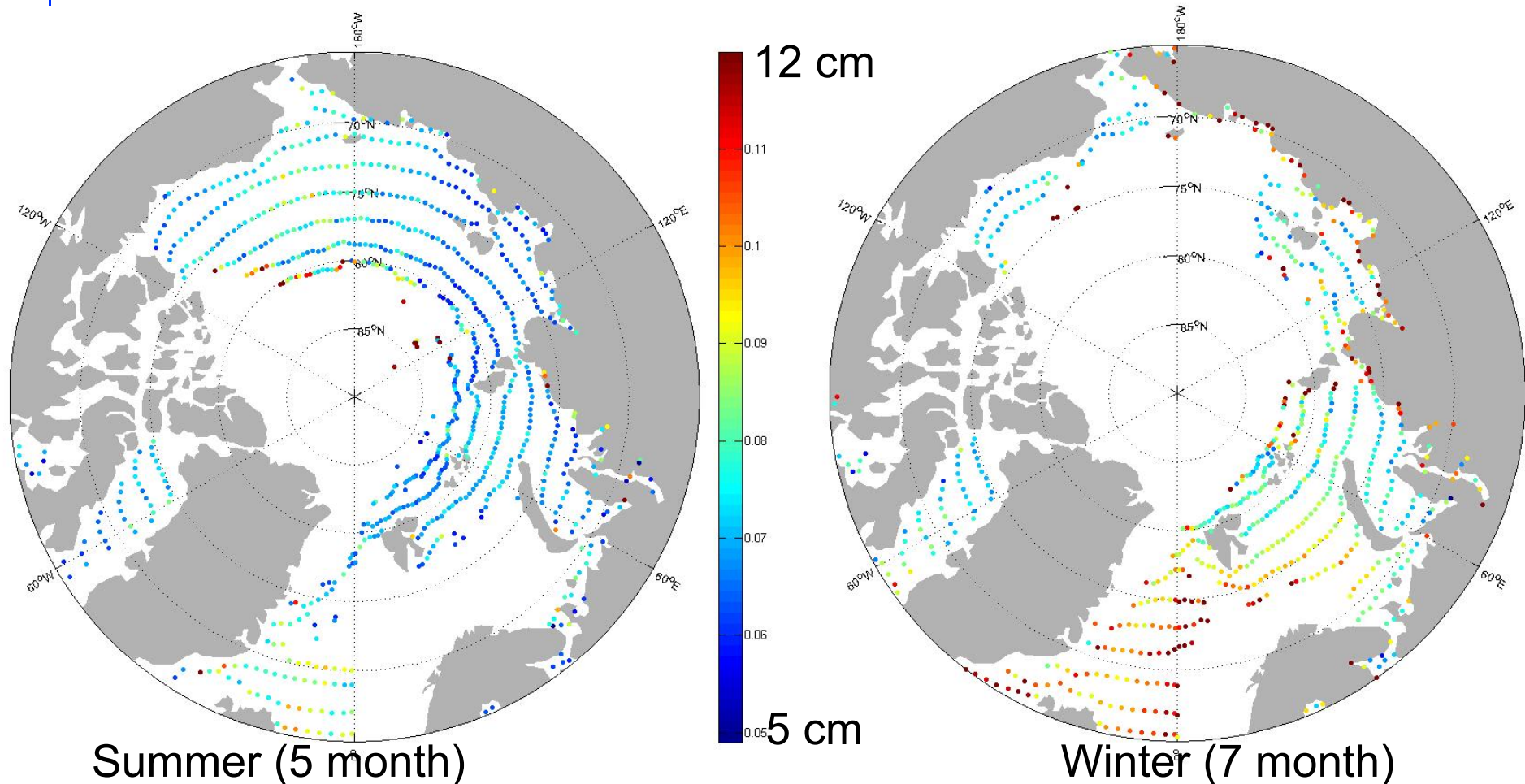
Minumum of 6 obs/sec required, Default corr applied.

# Peak Thress-hold retrack (R5) "average 1Hz std.dev in 2° blocks"





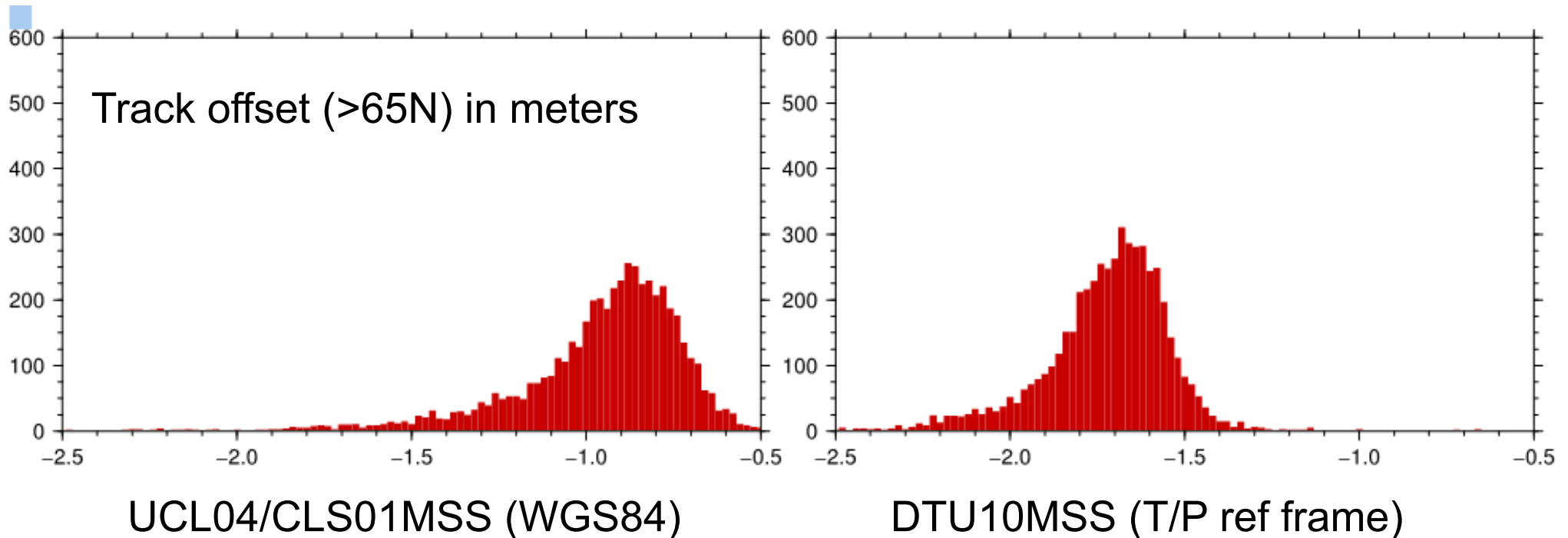
# Ocean retracking (R5) "1Hz std.dev"



**Ocean data could/should be retracked using i.e. SAMOSA retrackers.**

Notice: Only "few" will result in 1 Hz data

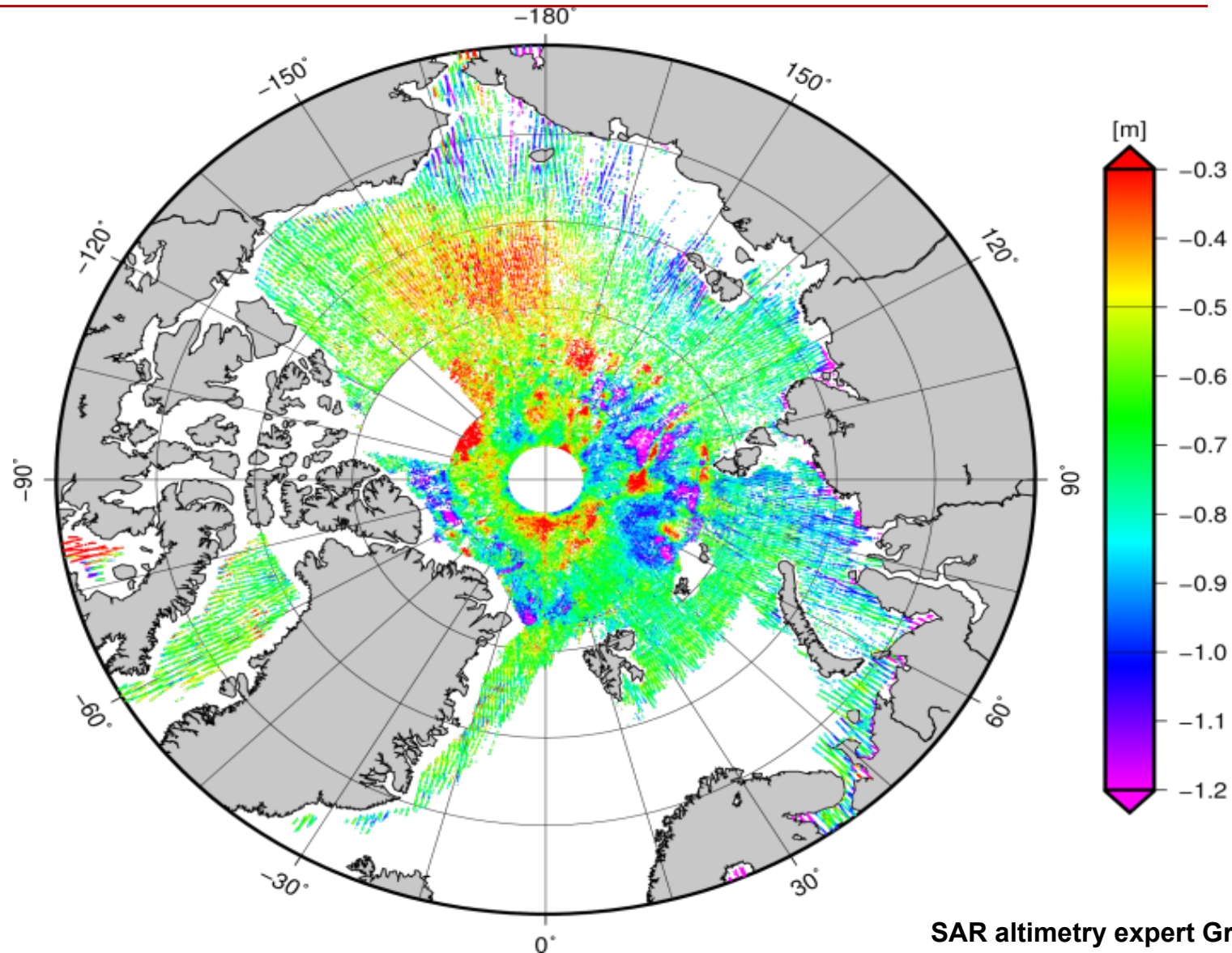
## Retracker offsets -> absolute height.



Found considerably higher scatter in track mean for UCL04/CLS01 MSS than DTU10MSS.

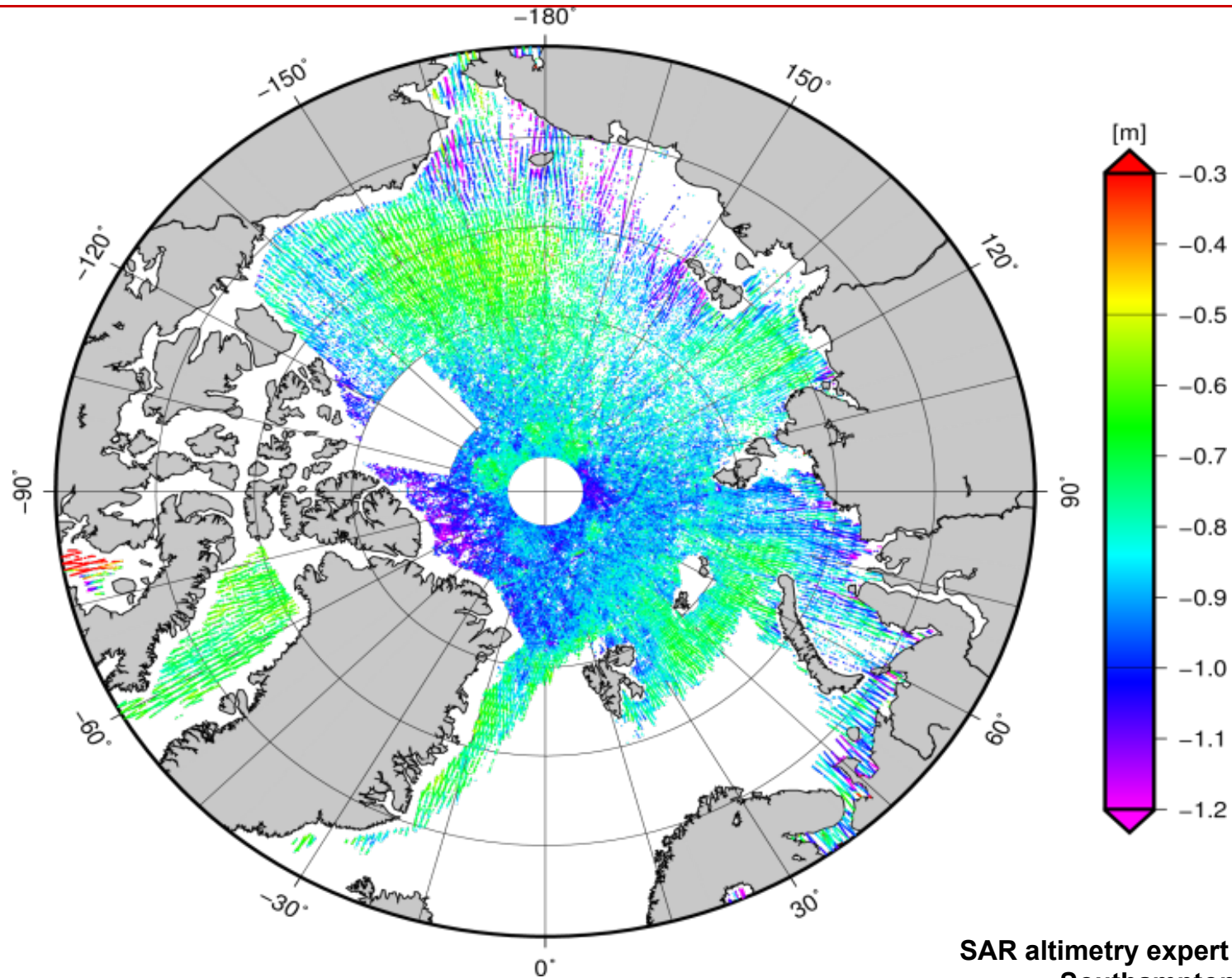
We found 0.7 meter constant value (retracker offset)

## C2 relative to UCL04/CLS01 MSS (ESA default)





## C2 relative to DTU10MSS)



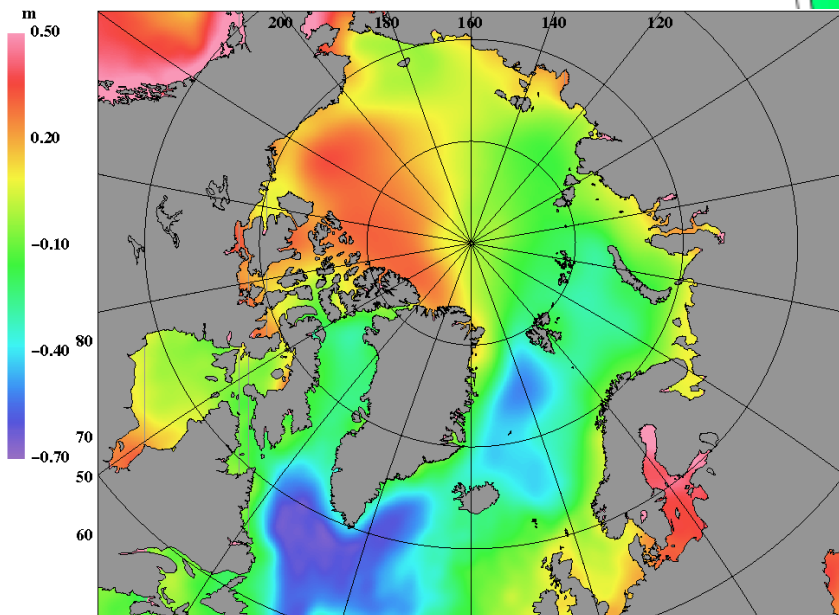
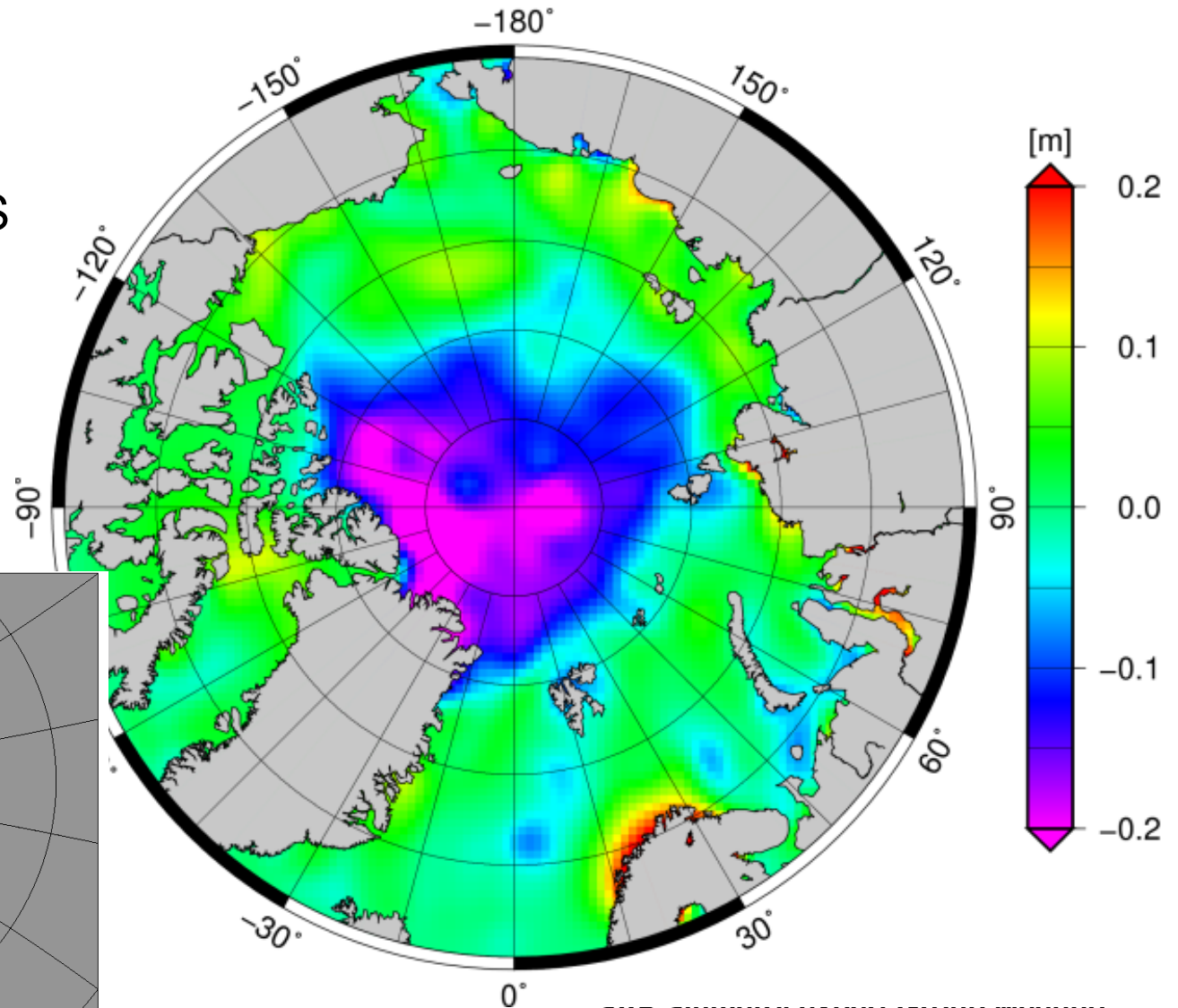


## Mean sea surface (DTU13MSS – DTU10MSS)

Gridded smoothed selected mean

To get proper 20 Year  
referencing. Adjusting  
all C2 data to DTU10MSS

Using GOCE to get  
MDT (Here DTU12MDT)  
For ocean currents.



## Conclusion

- ▶ Compared with conventional 1 Hz altimetry the 20 Hz Cryosat-2 SAR provide a wealth of new data and important information up to 88N.
- ▶ Basically the 20 Hz C2 lead data has 2-3 cm noise same or better "precision" as conventional 1 Hz observation
- ▶ Ocean data should be retracked by SAMOSA or other retracker
- ▶ Suggestion for discussion: reconsider 1 Hz computation for Arctic:
  - ▶ Requirement of 16 obs in 1 Hz => Removes 88%
  - ▶ Requirement of 10 obs in 1 Hz => Removes 59%
  - ▶ Requirement of 6 obs in 1 Hz => Removes 31%
- ▶ New DTU13MSS/MDT to be released at ESA Living Planet Symposium in September.

## Summary:

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### MSS:

- Evaluate LFIB effects on MSS,
- New DTU13 MSSs (both LFIB and NoLFIB) to be released at ESA Living Planet Symposium.

### MDT:

- New DTU13 MDTs to be released at ESA Living Planet Symposium,
- Develop marine geoid for absolute referencing of SSHs (including error characteristics),
- Improve marine geoid using in-situ gravity data.

The DTU12MDT mean dynamic topography model is available at:  
<http://www.space.dtu.dk>