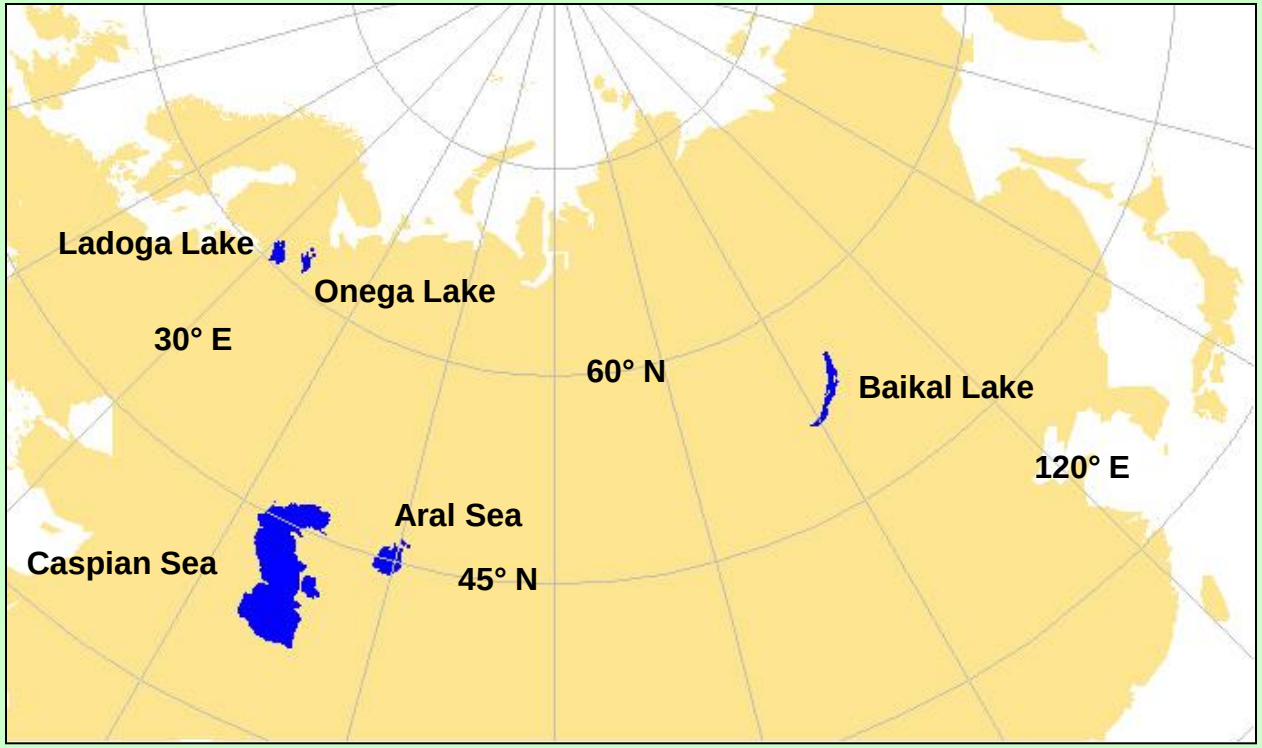
Radar altimetry and radiometry and in situ observations for study of ice cover of Eurasian water bodies and rivers

A.V. Kouraev, E.A. Zakharova, F. Rémy, M.N. Shimaraev, M.A. Naumenko, A. Ya. Suknev

University of Toulouse, France
LEGOS, Toulouse France
State Oceanography Institute

STUDY AREAS



Five largest Eurasian water bodies

Salt / fresh water

Seasonal ice cover - forming every year

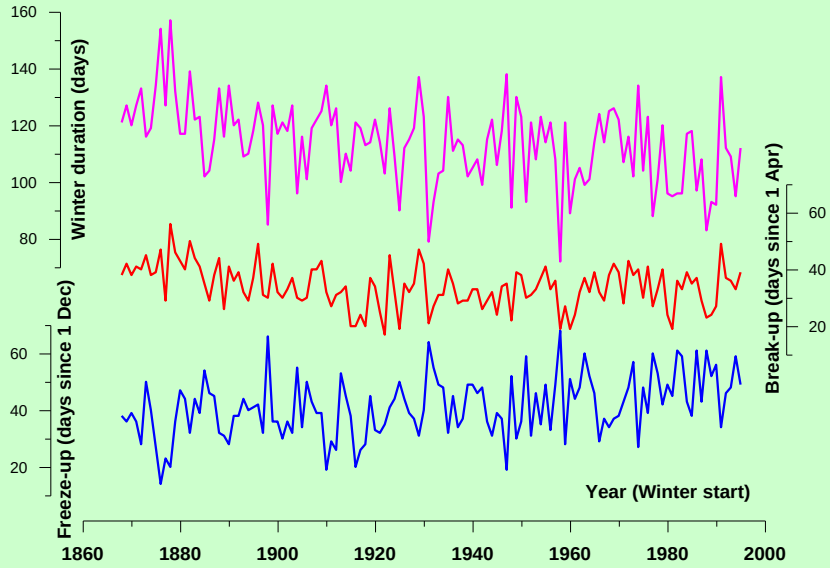
Full / partial ice coverage depending on winter severity

	Surface, km2	Volume, km3	Max depth, m	Mean depth, m	Comment
Caspian Sea	371000	78200	1025	211	World's largest inland water body
Baikal Lake	31500	23600	1637	749	Deepest lake in the world, 2nd largest in Eu
Ladoga Lake	18130	908	230	50	4th largest in Eurasia
Onega Lake	9891	280	120	28	5th largest in Eurasia
Aral Sea 1960	67000	1083	63	16	
Aral Sea 2004	16000	100	40	6	

Ice and snow for people and nature

Good indicator of large-scale climate change

Formation of hydrophysical fields



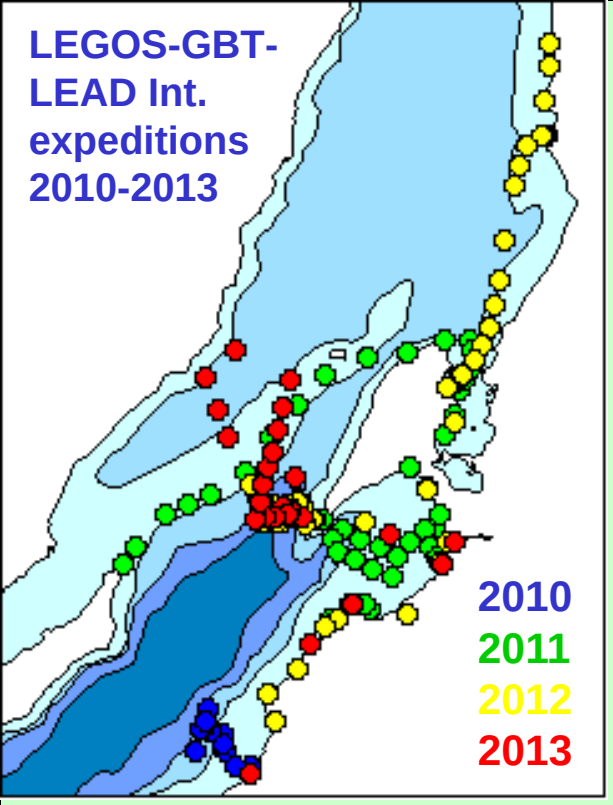
Baikal ice phenology and winter duration - Listvyanka station (since 1868)

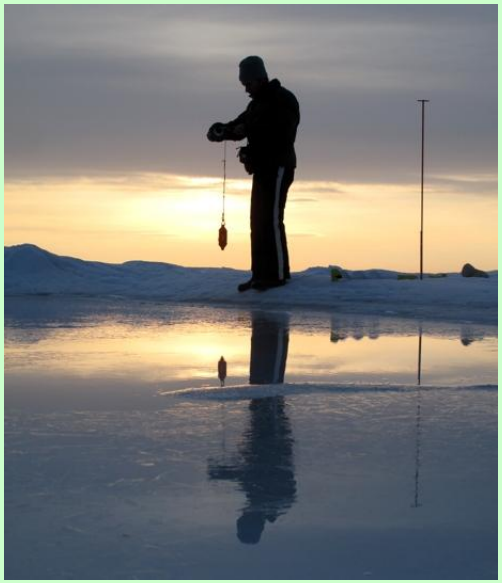
Influence on spring bloom of diatoms and primary production

Living conditions for endemic animals

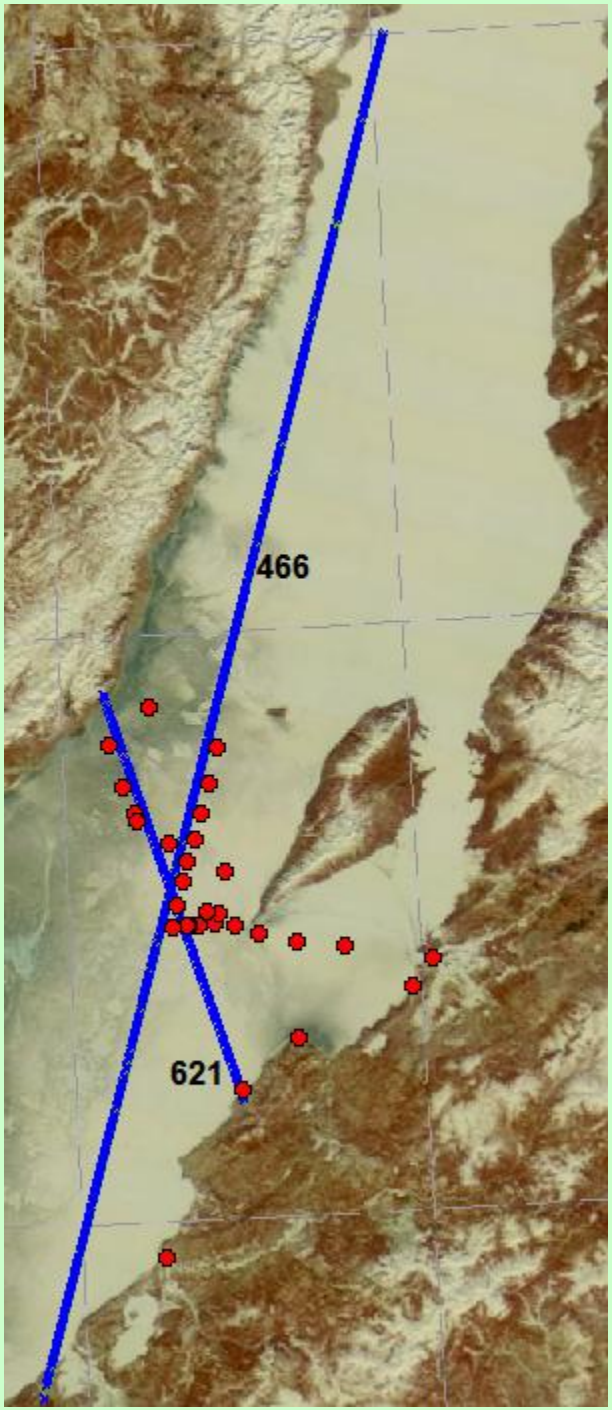
Practical aspects - transport on ice, fishing, tourism

Opening of ice route to Ol'khon island, 11 February, 2004





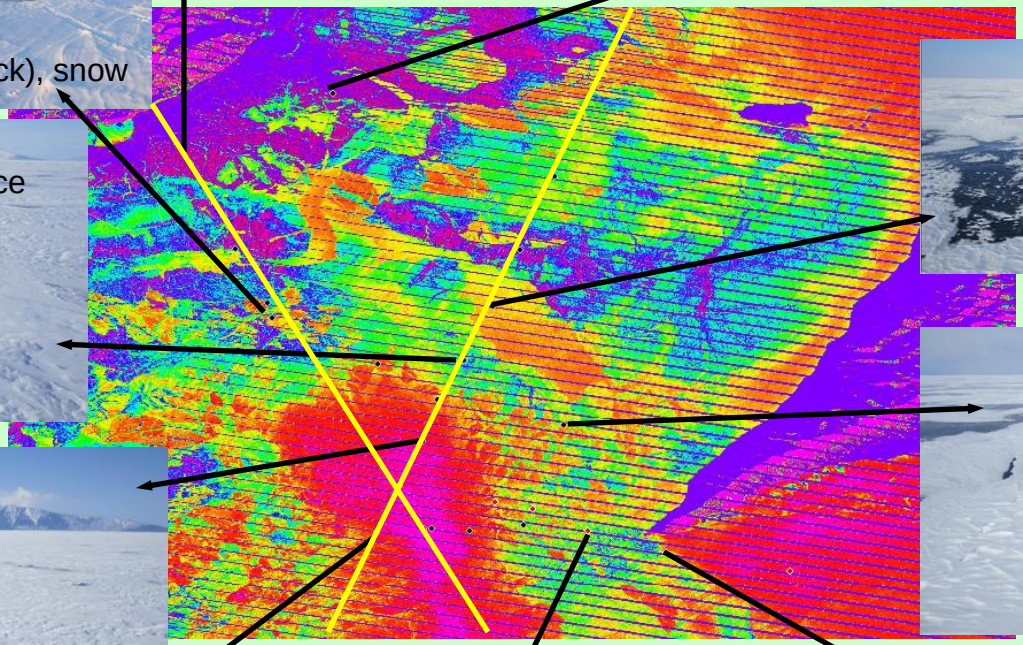
CNES TOSCA, ANR CLASSIQUE,
FP7 Monarch-A, CNRS PICS BaLaLaICA



March-April 2013: measures along the AltiKa tracks

Smooth, mostly clear ice

Rough, hummocky (1 cm thick), snow

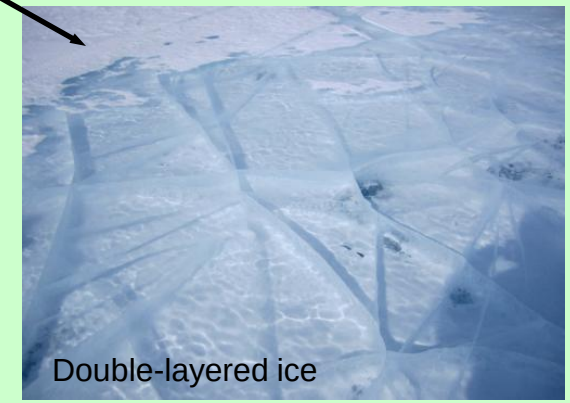


Snow, small patches
of clear ice

Smooth; congelated pancake ice

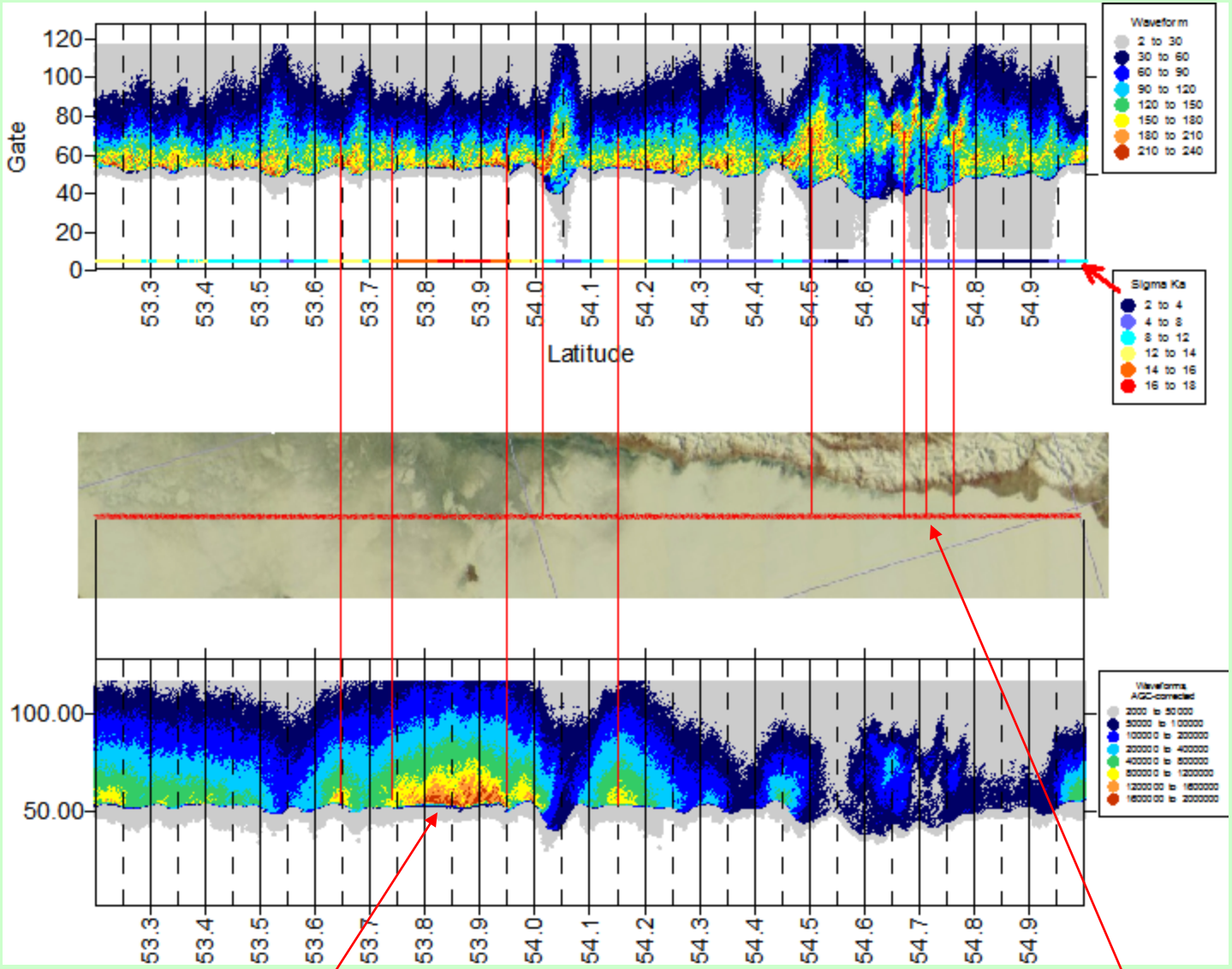
Snow-covered ice

Snow, small patches
of clear ice



Double-layered ice

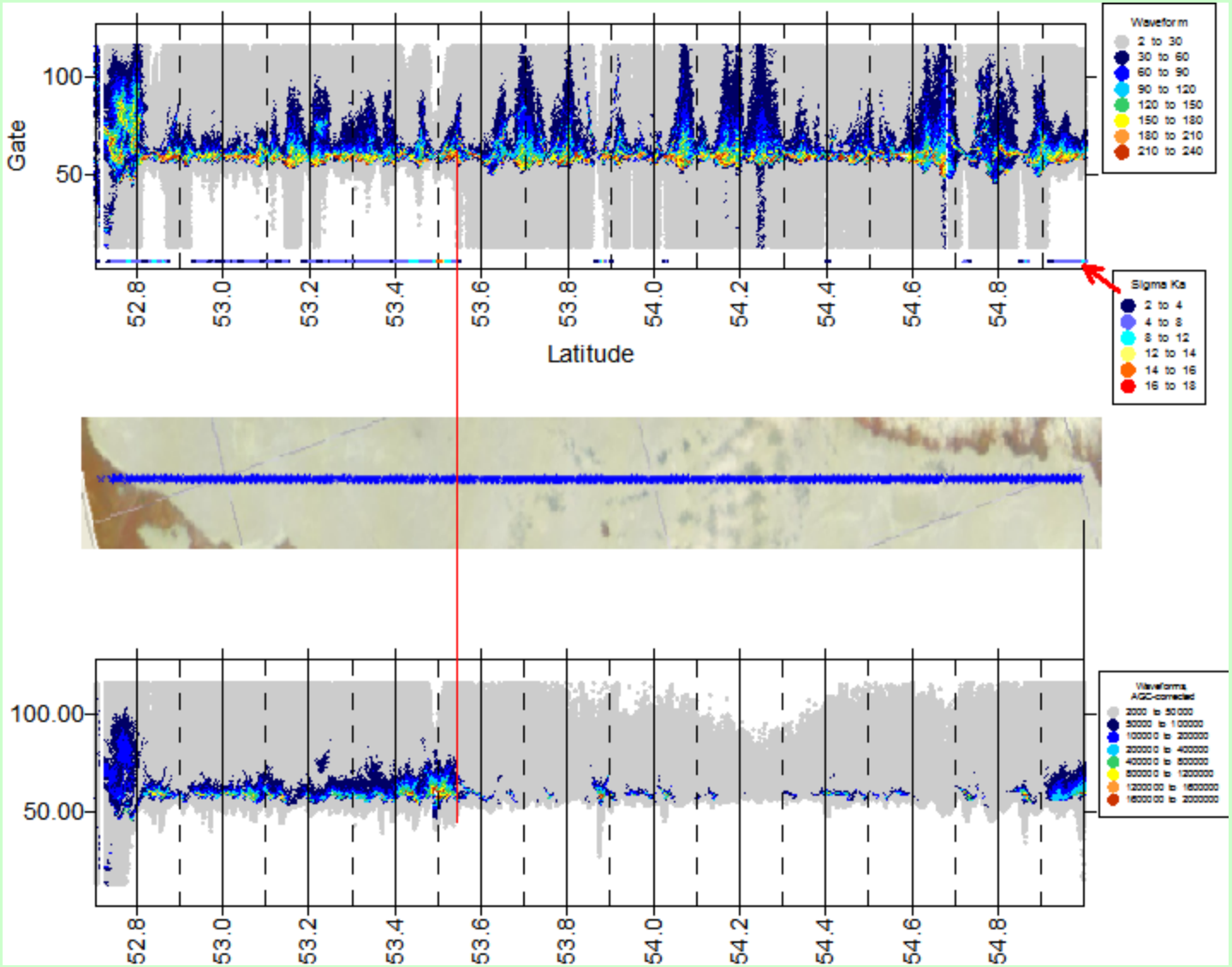
466, cycle 1, 30 March 13



High backscatter when no snow

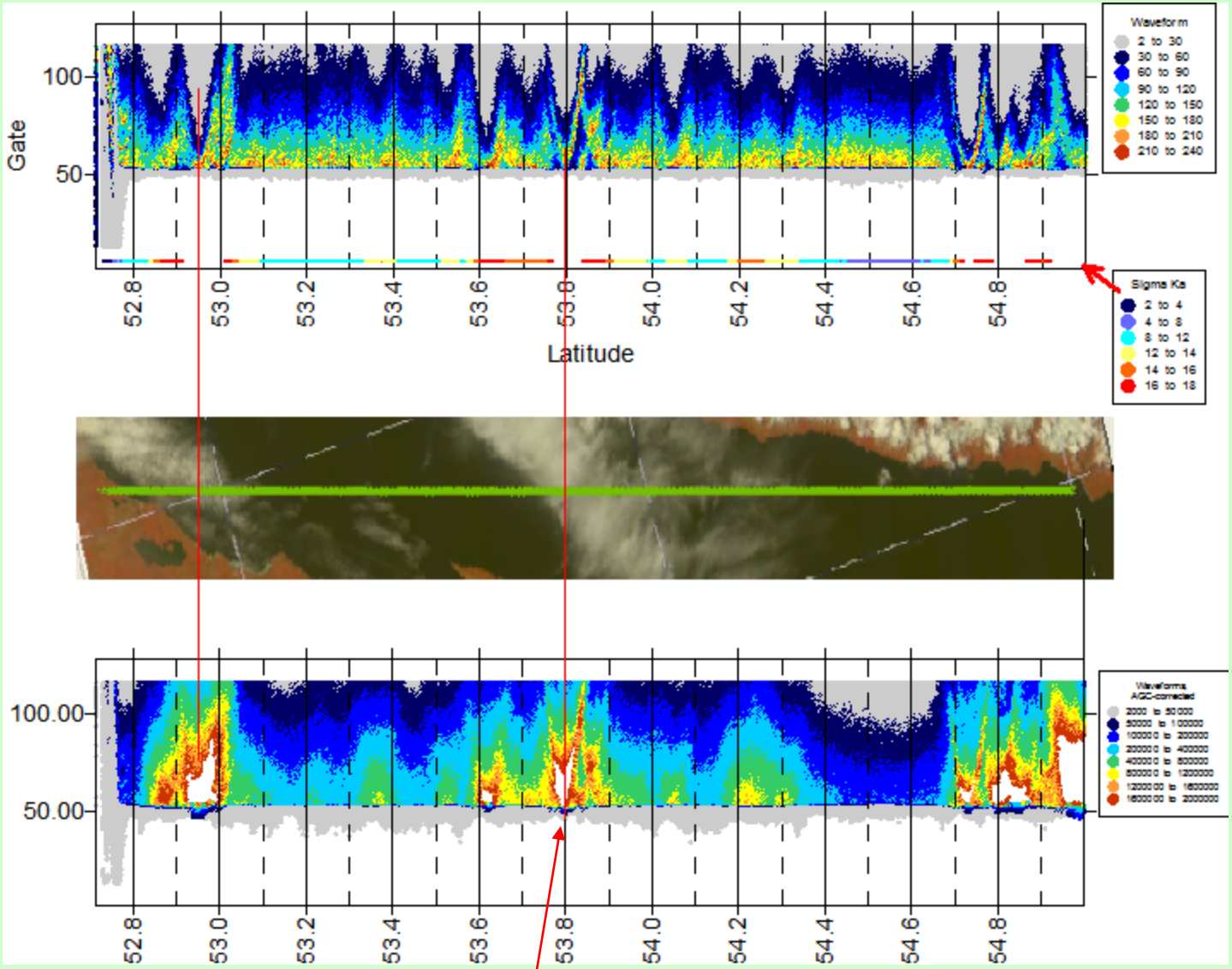
Open ice in coastal areas

466, cycle 2, 4 May 13



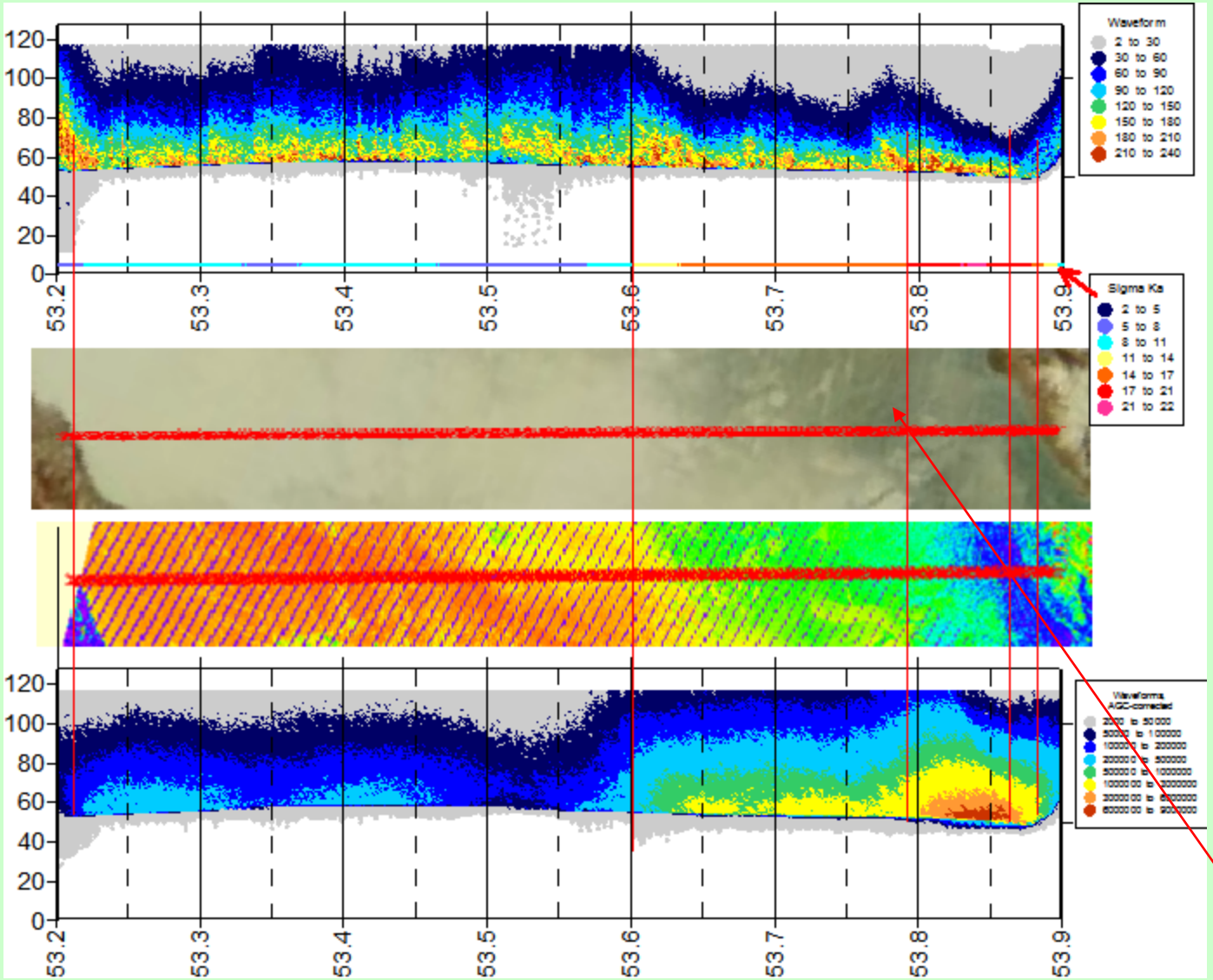
Dramatic decrease of backscatter

466, cycle 3, 8 June 13

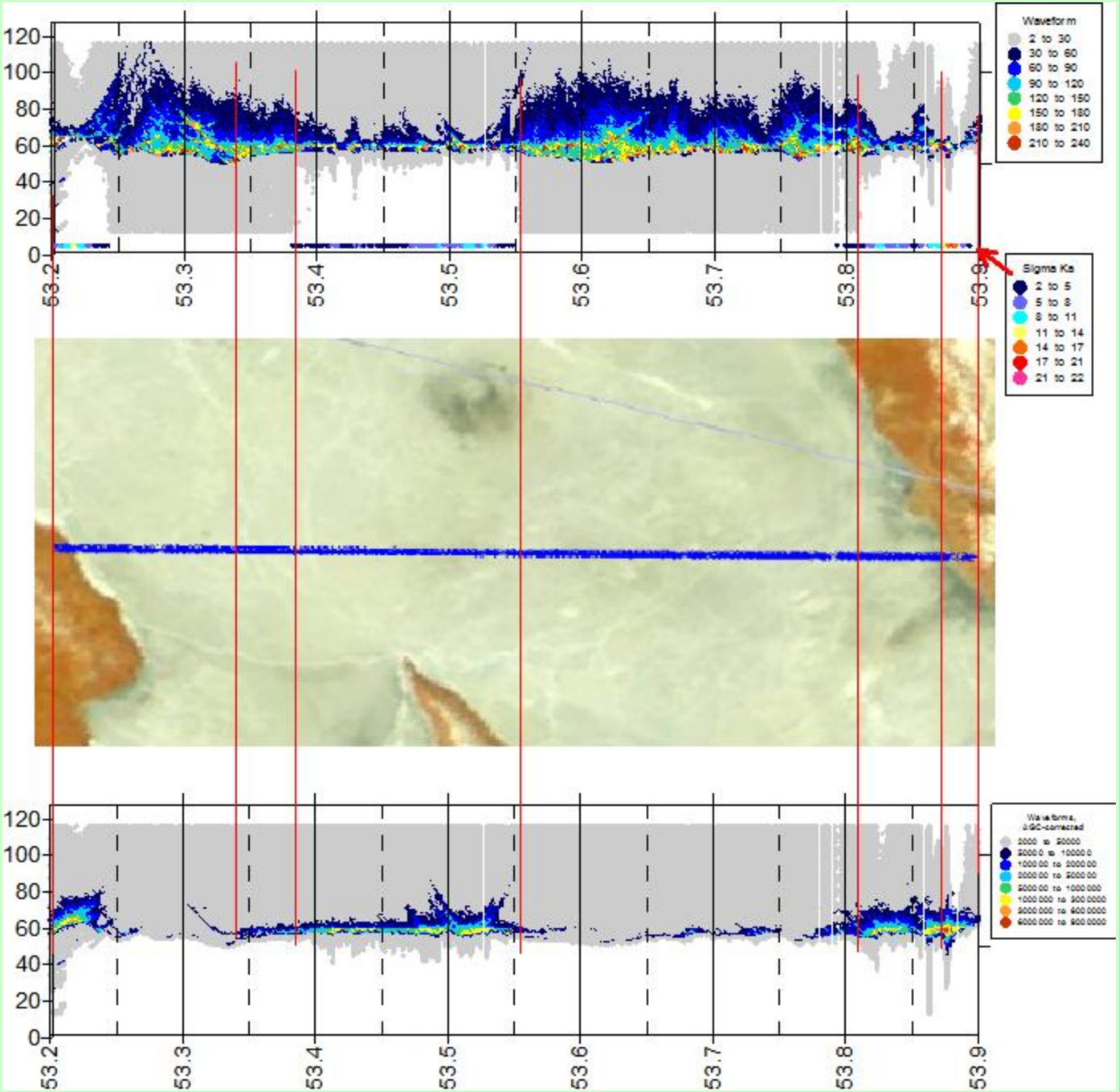


Open water - but strange high backscatter

621, cycle 1, 4 April 13



High backscatter when no snow

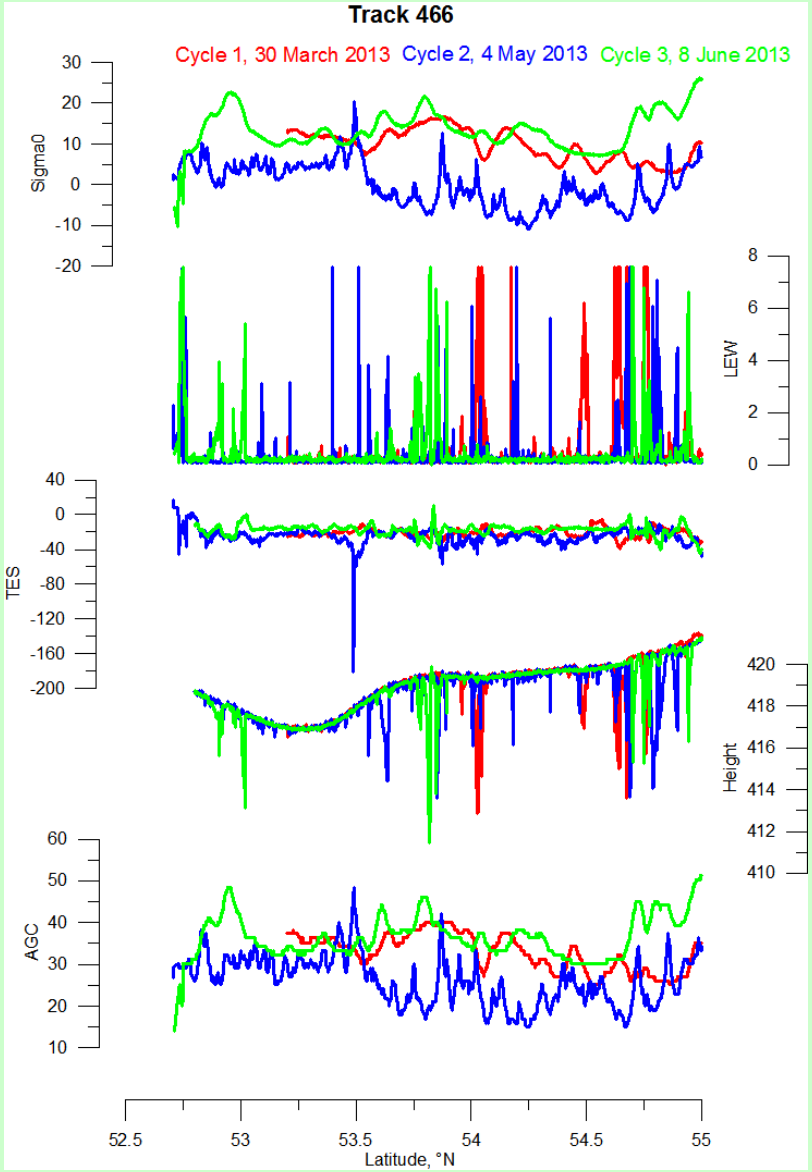


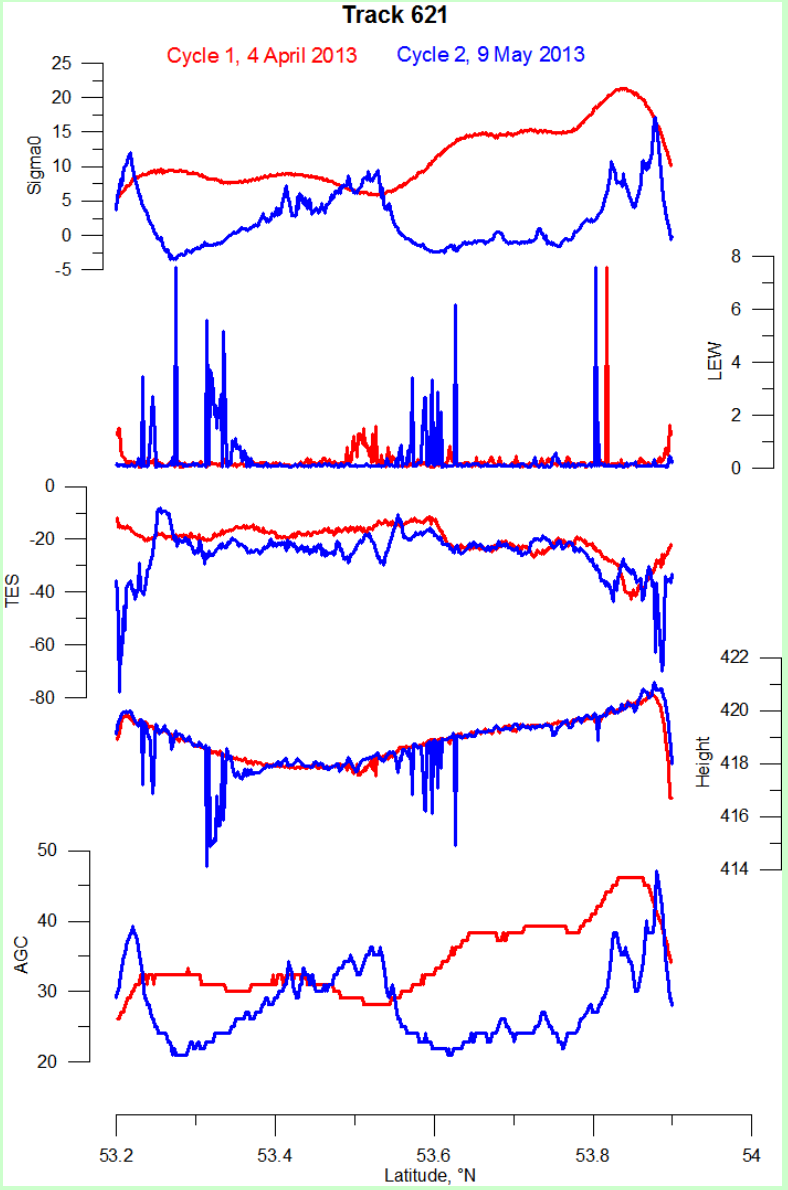
621, cycle 2
9 May 13

Dramatic decrease of backscatter

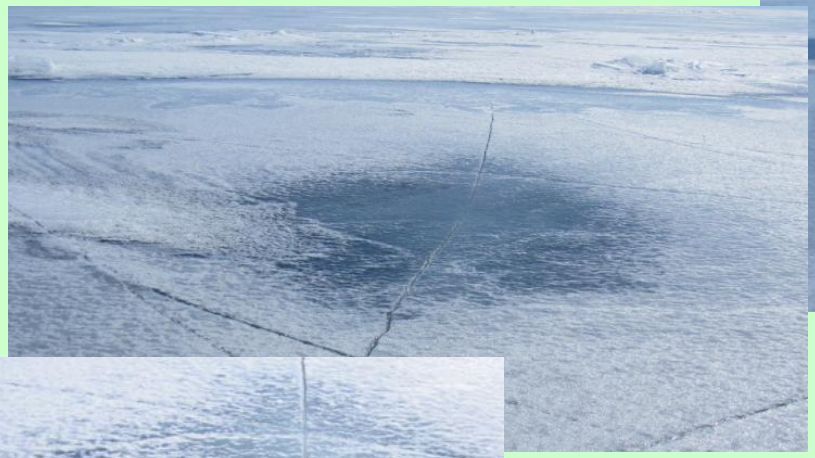
Why backscatter changes so much?

Ice thinning, methamorphism, structure



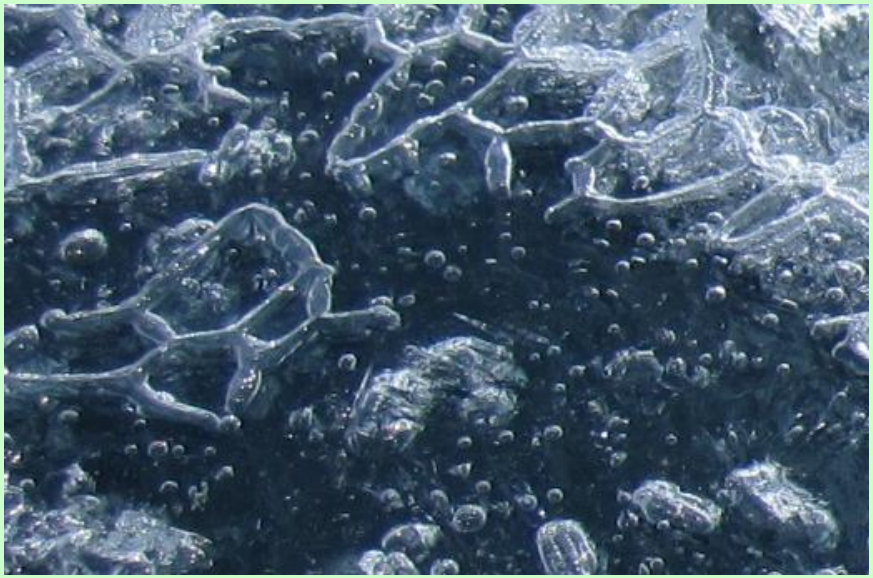


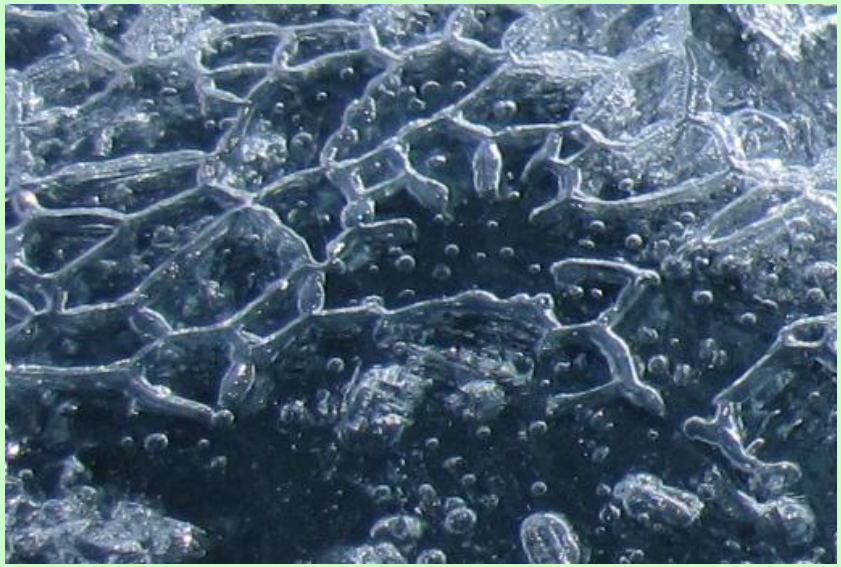
Ice structure



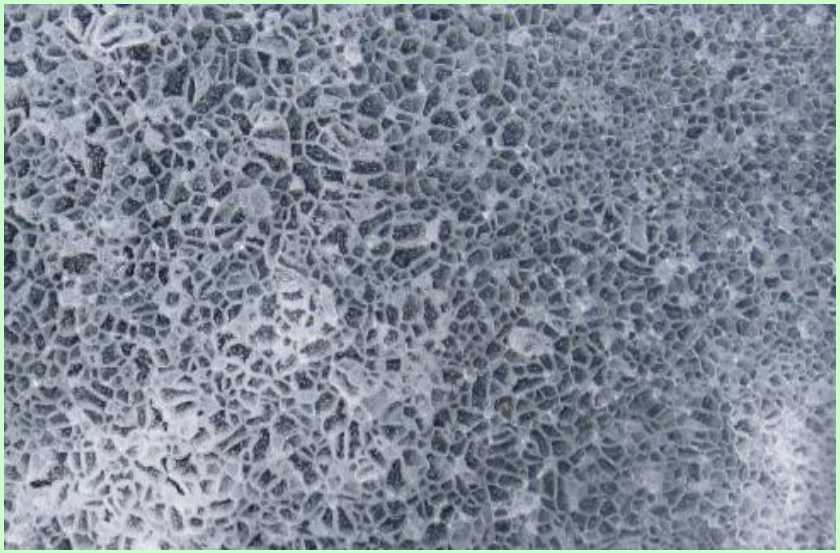
Air channels

Air channels formation in 9 min
Influence on albedo!





Needle ice



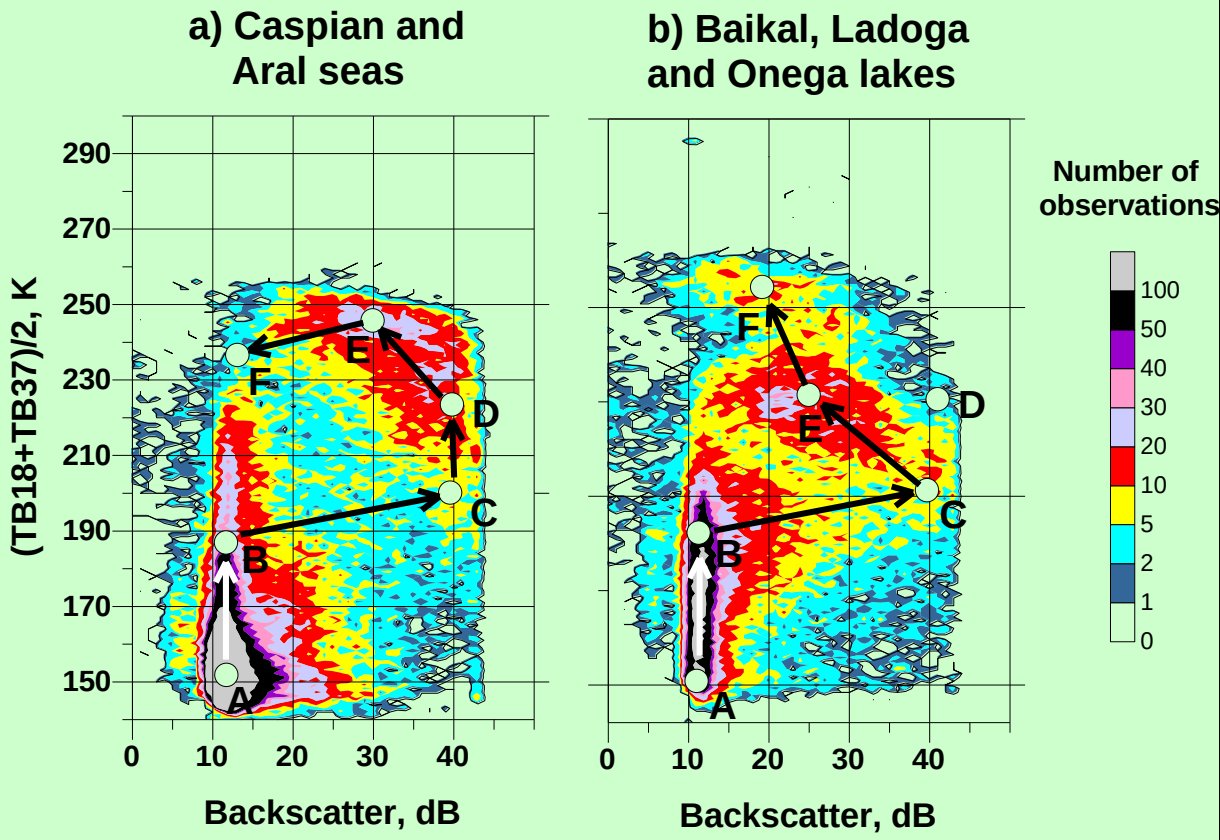
Simultaneous active and passive microwave data for ice cover studies

Combination of simultaneous active (altimeter) and passive (radiometer) microwave data

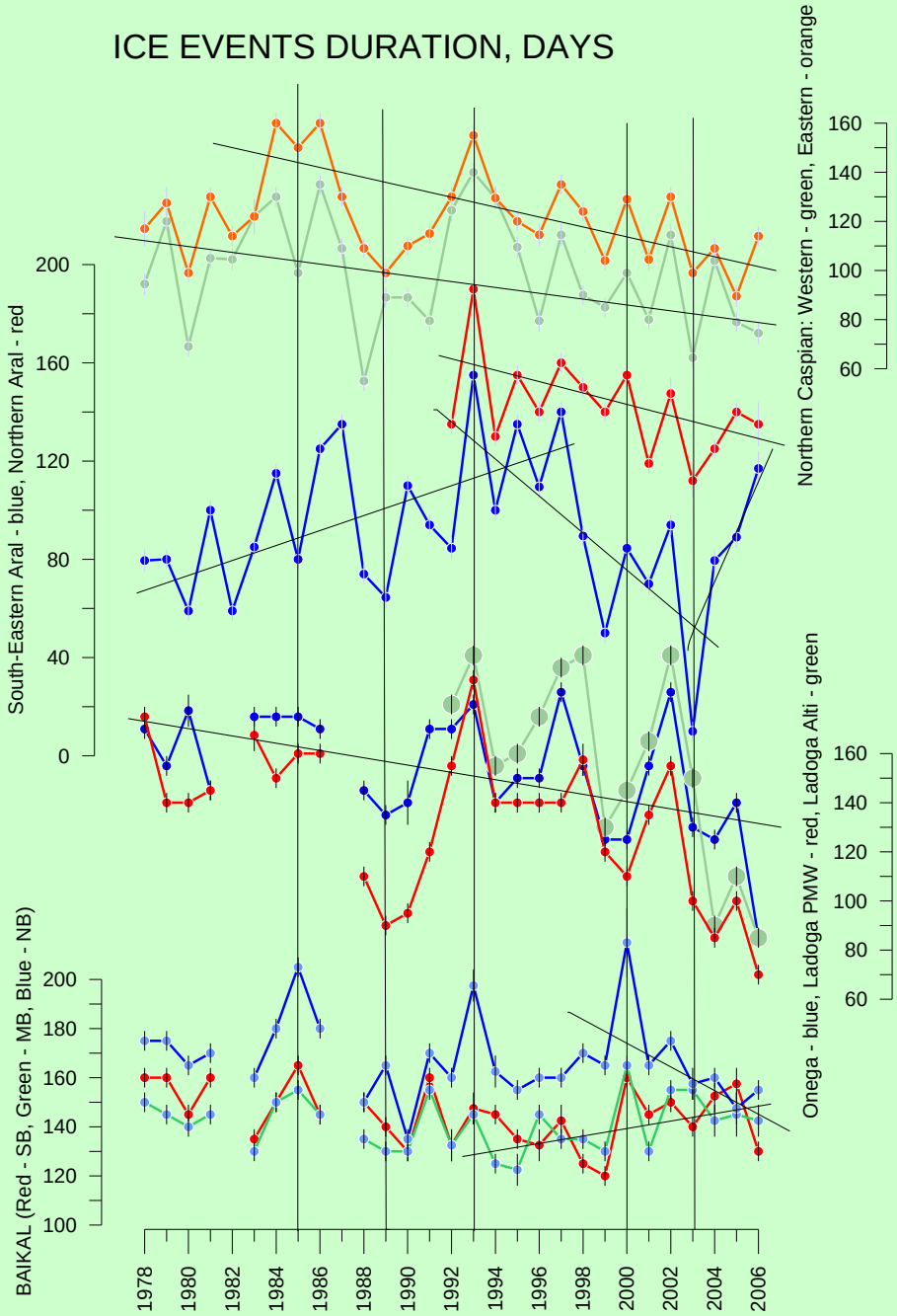
Altimetry method

Ice / water discrimination methodology: developed, validated and tested for seas and lakes

Kouraev et al.,
2003 Polar Research
2004 JMS
2004 IEEE TGRS
2007 RSE
2007 L&O
2008 SiG



Schematic representation of the temporal evolution of T/P observations in the space of backscatter vs. TB/2. Schema is overlaid on two-dimensional histograms (total summed values) for Caspian and Aral seas (a) and Baikal, Ladoga and Onega Lakes (b)



Shorter winters - but not everywhere!

Caspian sea - constant gradual warming

Aral sea - cooling followed by warming

Ladoga and Onega - very similar, recent warming

Baikal - warming in the north, but cooling in the center and south

Some winters are typical (cold 1993/94) but mostly regional character

Conclusions

Large sensitivity of Ka-band backscatter

Promising new tool of simultaneous active and passive observations in the same band