PECHORA-KARA SEAS COASTS HYDROMETEOROLOGICAL STRESS EVOLUTION AND INTENSIFICATION IN RECENT 35 YEARS

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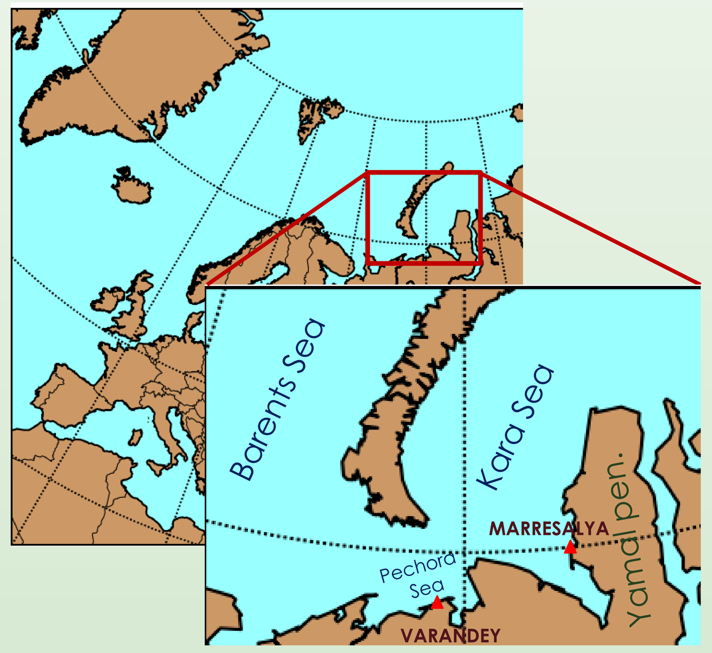
I. Arctic coasts retreat and quite rapidly

Vize polar station

Varandey polar station

Arctic coasts retreat rate is about 0.5 - 2 m/year. If the coastal cliff is composed of ice-rich material or contains (ice bodies (ice wedges or chunks, massive ground ice) the coastal destruction may reach 5 – 10 m/year.

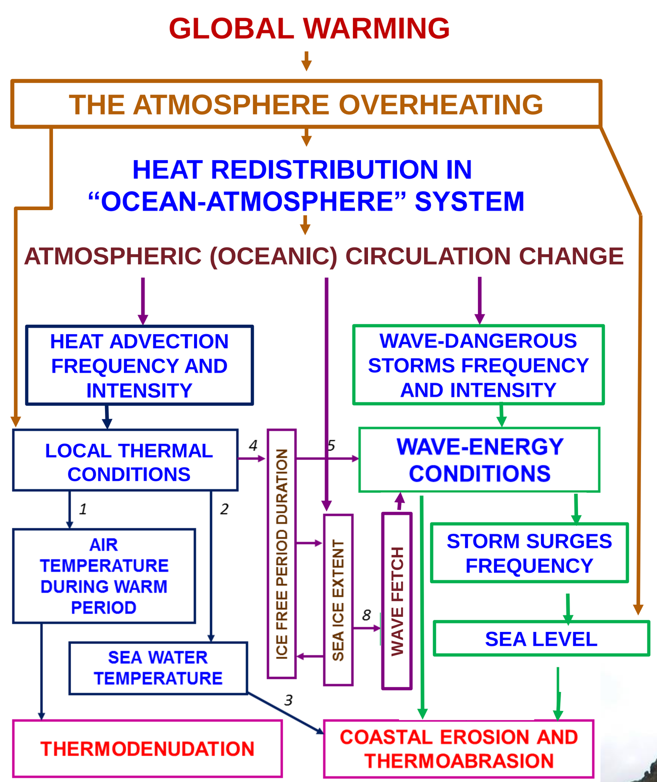


II. In recent years some coasts displayed accelerated erosion

Reference	Region	Method	Erosion rates, m/year (averaged for the indicated periods)				
Jones, 2009	Alyaska, Beaufort Sea	Satellite images		1955-79 6.8	1979-2002 8.7		2002-2007 13.6
Vasiliev, 2011	Western Yamal, Kara Sea	Direct field observations		1978-81 ~1.2	1988-1992 1.7-3.5	1997-2002 ~1	2006-2010 2.5
Grigoriev, 2006	Eastern Siberian Seas	Literature sources and others	~1935-45 ~6-7	~1955-65 ~3	~1985-1995 ~5-6	The beg. of 2000s ~2	

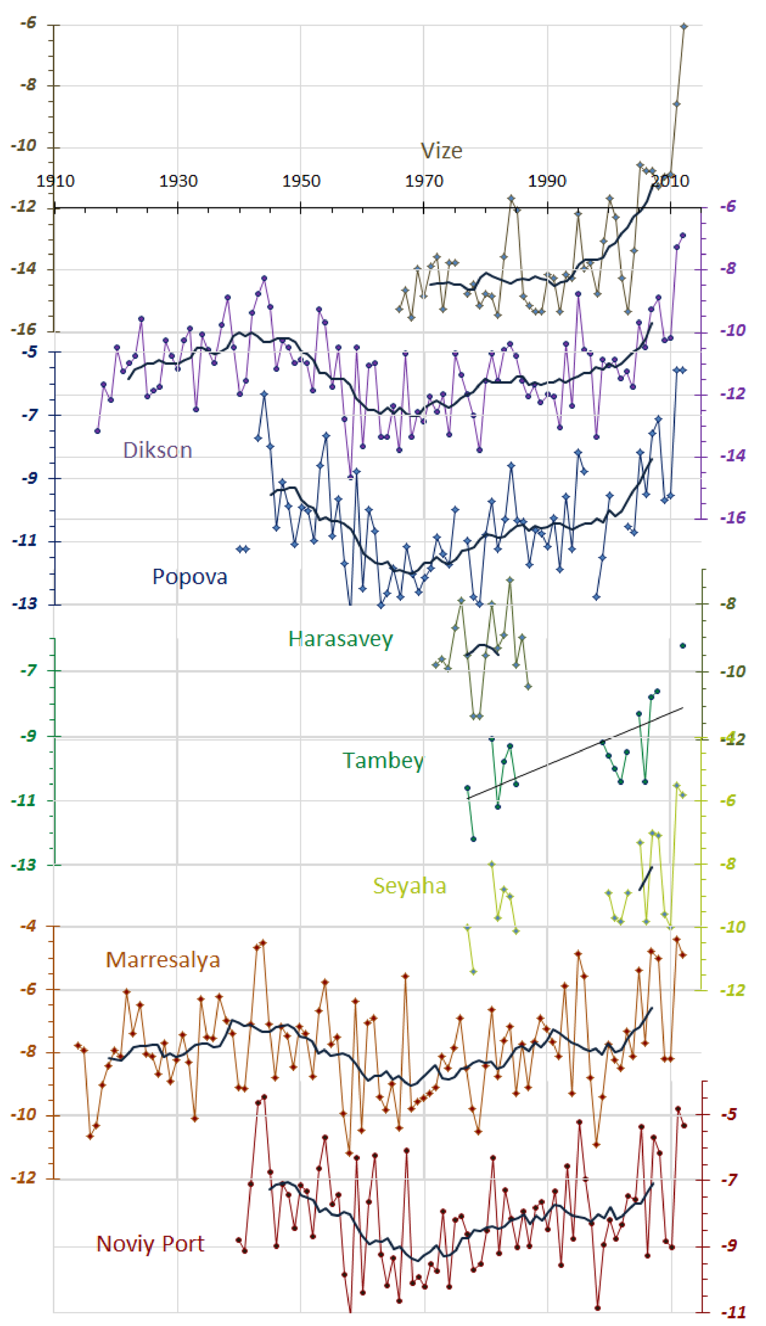
All the authors indicate the increased retreat rates of coastal erosion for different Arctic regions. Some authors indicate also that there were periods of heightened values in about 1985 – 1995 and after 2002 and low values in about 1995 - 2002

III. Arctic coastal erosion depends mainly on hydrometeorological factors



IV. Climate changes and drives coastal dynamics

Kara Sea stations year mean temperature with 11-year running mean



DO CHANGING WAVES, ICE AND TEMPERATURE COOPERATE IN COASTAL RETREAT ACCELERATION OR COMPENSATE EACH OTHER **?**

V. Methods

The observation data from Varandey and Marresalya polar stations are used

The amount of heat added to or extracted from the ground and the permafrost during the warm and cold periods is assessed by **air thawing and air freezing index** (I_{at} and I_{af}, respectively) showing the number of positive/negative °C·days per year (Andersland and Ladanyi, 2004)

Residual mass curve method for periods detection

$$X\_N_i = \frac{X_i/\bar{X} - 1}{C_v} = \frac{X_i - \bar{X}}{\delta}$$

$$X\_RM_i = \sum_1^i X\_N_i$$

High-value period
$X_i > \bar{X} \rightarrow X\_N_i > 0 \rightarrow X\_RM_i$ ascends

Low-value period
$X_i < \bar{X} \rightarrow X\_N_i < 0 \rightarrow X\_RM_i$ decends

Popov-Sovershaev method for wave energy assessment
(Popov, Sovershaev, 1982)

Deep water conditions

$$E = 3 \times 10^{-6} V^3 x \times p \times n,$$

where V – wind velocity, m/sec;
x – wave fetch, km,
p - wave-dangerous winds frequency,
n – ice-free period duration, days.

Shallow water conditions

$$E = 2 \times 10^{-6} \left(\frac{gH}{V^2}\right)^{1.4} V^3 x \times p \times n.$$

References

Andersland, O.B. and Ladanyi, B., 2004. Frozen Ground Engineering, 2nd Edition John Wiley & Sons, Hoboken, New Jersey.

Jones, B.M. et al., 2009. Increase in the rate and uniformity of coastline erosion in Arctic Alaska Geophysical Research Letters 36(L03503), 1-5.

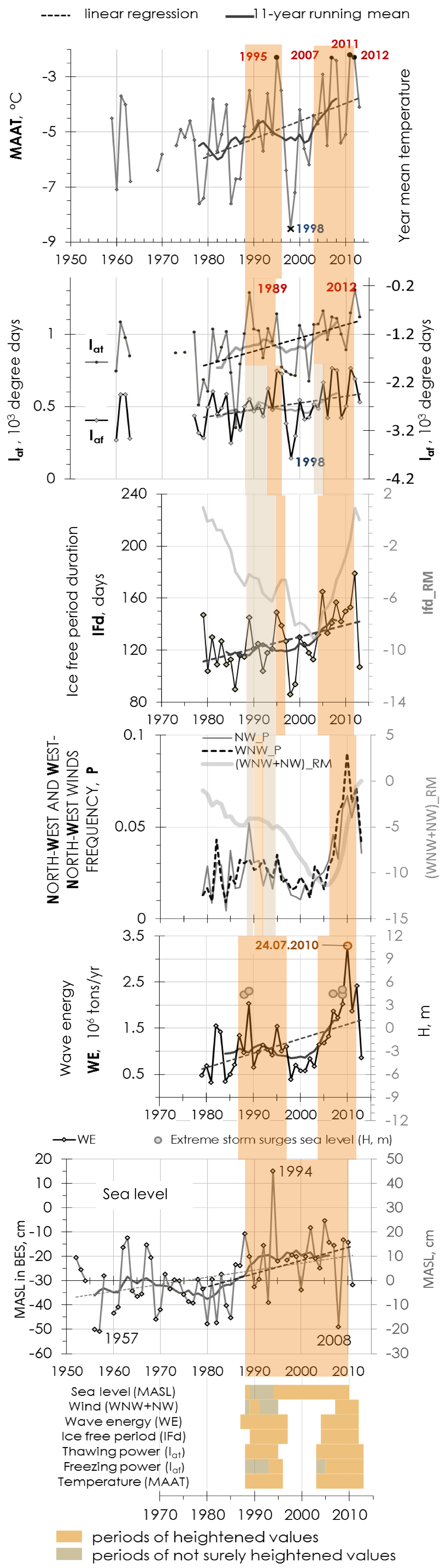
Vasiliev, A.A., Shirokov, R.S., Oblogov, G.E. and I.D., S., 2011. Coastal Dynamics of the Western Yamal. Kriosfera Zemli XV(4), 63-65.

Grigoriev, M.N., Razumov, S.O., Kunitzky, V.V. and Spektor, V.B., 2006. Dinamika Beregov Vostochnykh Arkticheskikh Morei Rossii: Osnovnye Faktory, Zakonomernosti i Tendencii (*Dynamics of the Russian East Arctic Sea coast: major factors, regularities and tendencies*), Kriosfera Zemli (Earth's Cryosphere) 10(4), 74-94.

Popov, B.A. and Sovershaev, V.A., 1982. Nekotoryye cherty dinamiki Arkticheskikh beregov Azii (*Some features of the coastal dynamics in arctic Asia (Sea coasts)*), Voprosy geografii 119 (Morskie berega), 105-116.

VI. Two periods of increase: 1979 – 1995, 2003 – 2011(…)

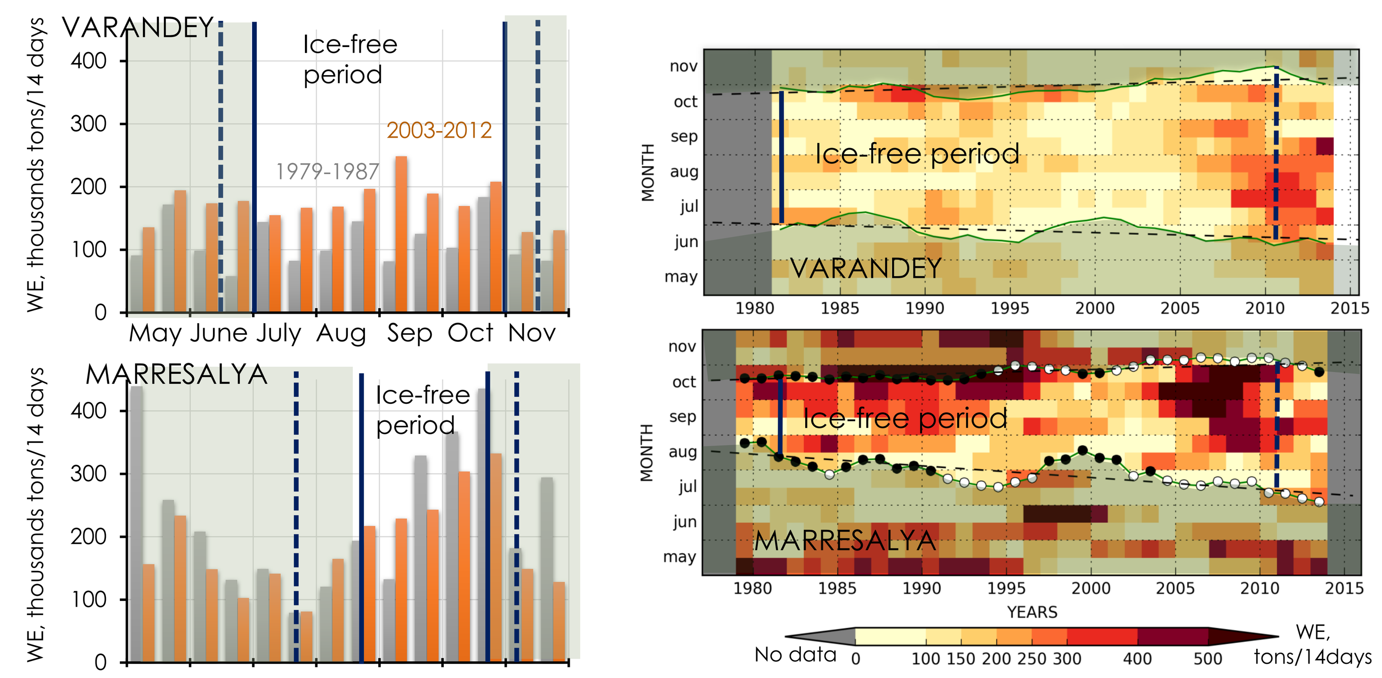
Hydrometeorological factors evolution. Varandey



VII. Wave energy and ice-free period

Varandey. Wind wave energy flux got 72% higher due to both atmospheric circulation change and 16% due to ice-free period extension: energetic stress has increased by ~90%

Marresalya. Wind wave energy flux could get 62% higher due to ice-free period extension in case of stable atmosphere conditions. But due to AC change the increase amounts only 50%.



RESULTS

HYDROMETEOROLOGICAL FACTORS **ENHANCE** THE EROSION OF ARCTIC WESTERN COASTS **JOINTLY** !

THE HYDROMETEOROLOGICAL STRESS **HAS INCREASED BY 30 – 100%** FOR PECHORA AND KARA SEAS WESTERN COASTS SINCE 1979

WESTERN ARCTIC COASTS HAVE ***STICK-SLIP*** DYNAMICS

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