



Arctic HSE seminar 1

Ice behavior in northern regions, availability and need for metocean & ice data.

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24th March 2014

DEFINITIONS & CAUTIONARY NOTE

Reserves: Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves.

Resources: Our use of the term “resources” in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

Resources plays: our use of the term ‘resources plays’ refers to tight, shale and coal bed methane oil and gas acreage.

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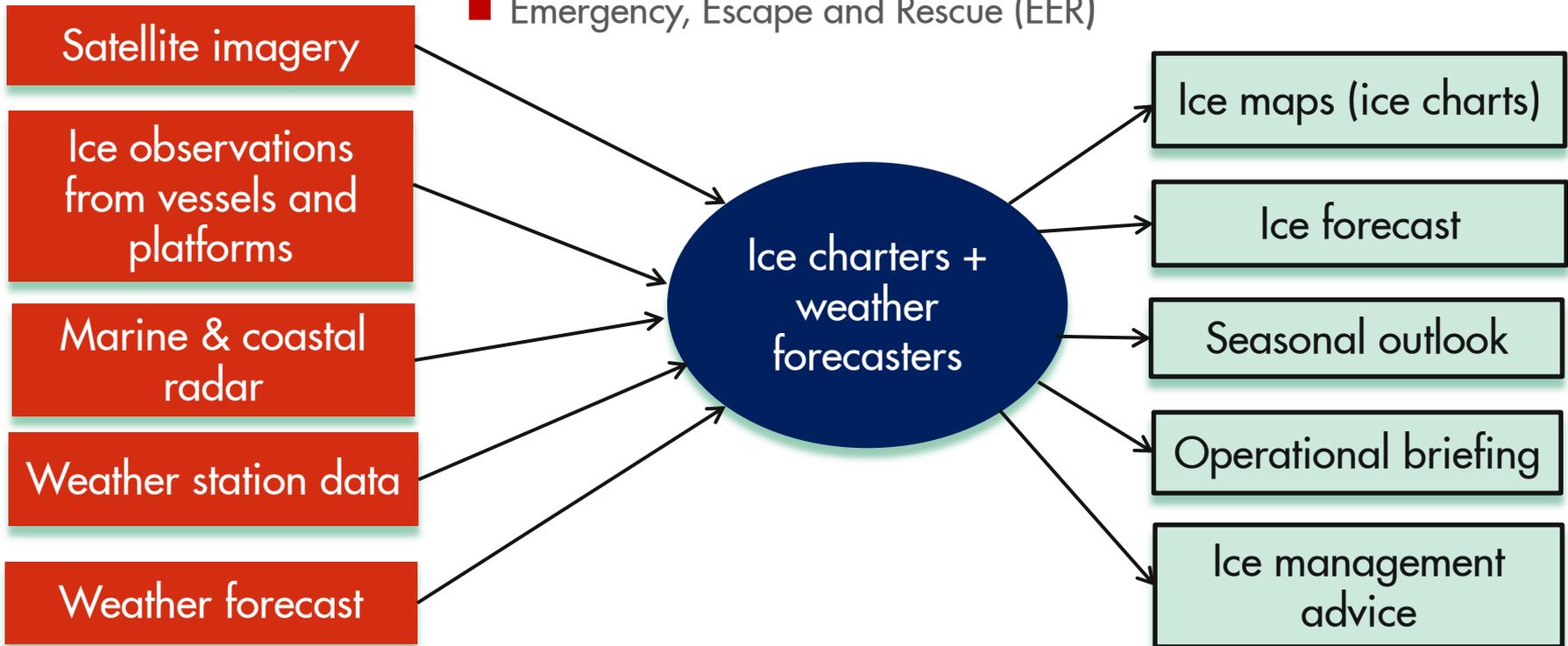
We use certain terms in this presentation, such as discovery potential, that the United States Securities and Exchange Commission (SEC) guidelines strictly prohibit us from including in filings with the SEC. U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain this form from the SEC by calling 1-800-SEC-0330.

THE ARCTIC

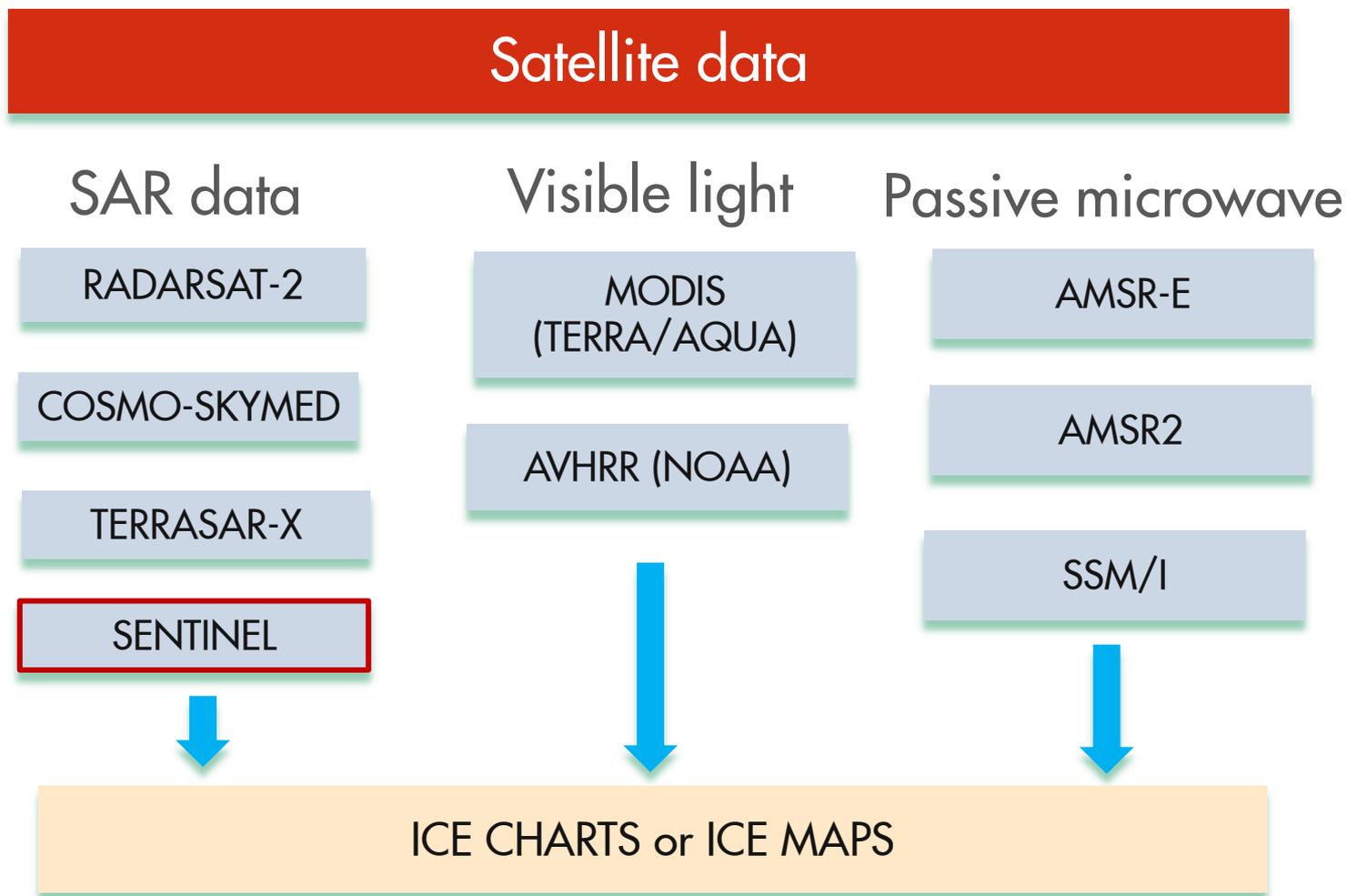


ICE DATA NEEDED FOR OPERATIONAL SUPPORT (1)

- Seismic operations
- Drilling operations
- Marine Logistics
- Oil spill response
- Platform Supply
- Geotechnical surveys
- Emergency, Escape and Rescue (EER)



SATELLITE DATA FOR OPERATIONAL SUPPORT



OBSERVATIONS MADE FROM PLATFORMS/VESSELS

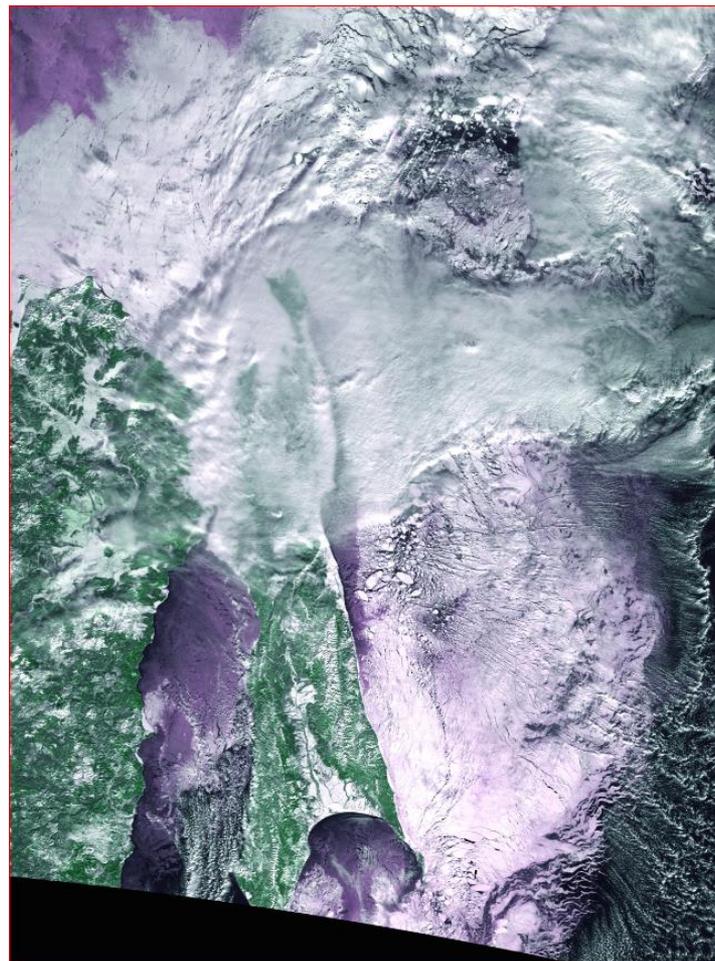
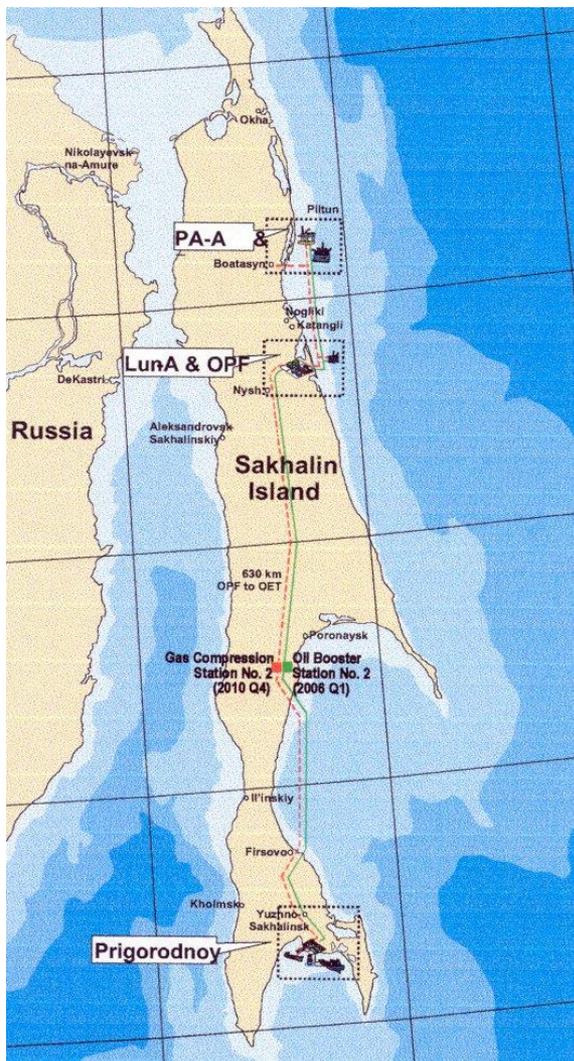


A typical view of the type of rough pack ice conditions seen on the northeast Sakhalin shelf, in this case, those observed around the Molikpaq in March 2000.

Monitoring of (typically):

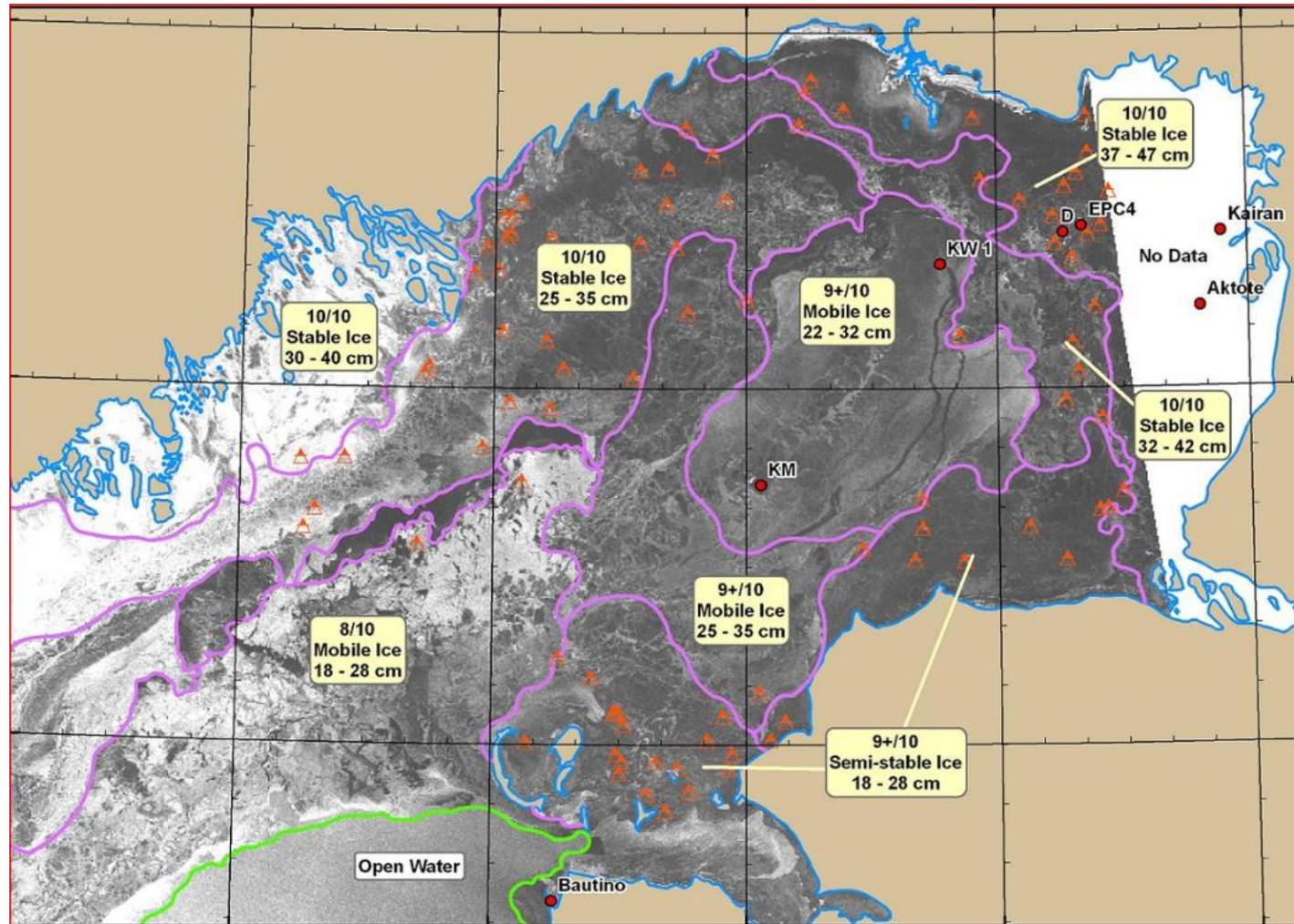
- Weather conditions
 - Air temp
 - Visibility
 - Wind
 - Cloud height
- Ice concentration
- Ice thickness (mean/max)
- Ice drift
- Floe sizes
- Ridge density
- Sail height (mean/max)
- Ice rubble against structure

SATELLITE IMAGERY - EXAMPLE (NE COAST OF SAKHALIN)



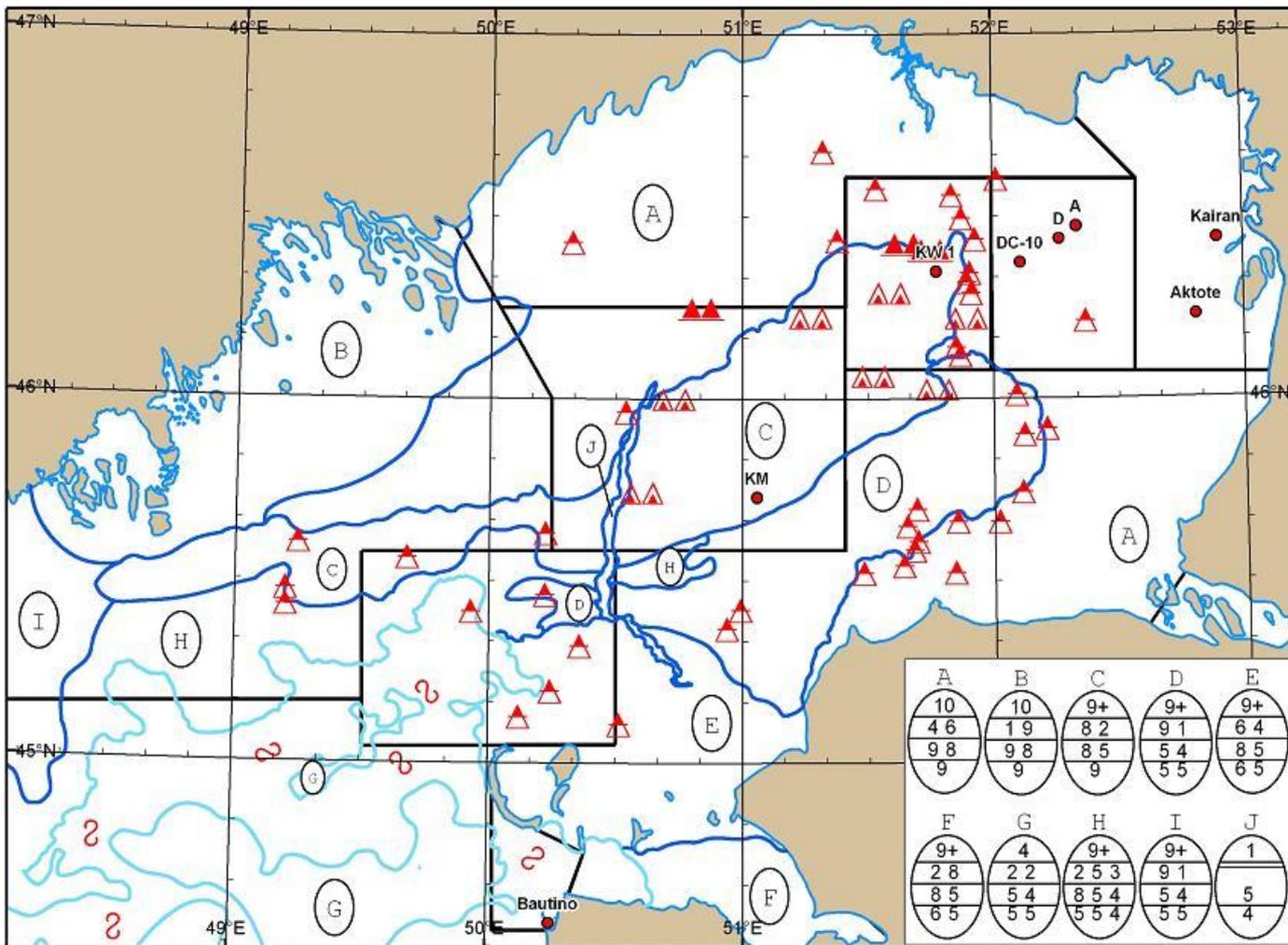
A MODIS image (available each day)
(4-Feb-2003)

SIMPLE ICE CHART FOR NE CASPIAN – TO BE DISTRIBUTED



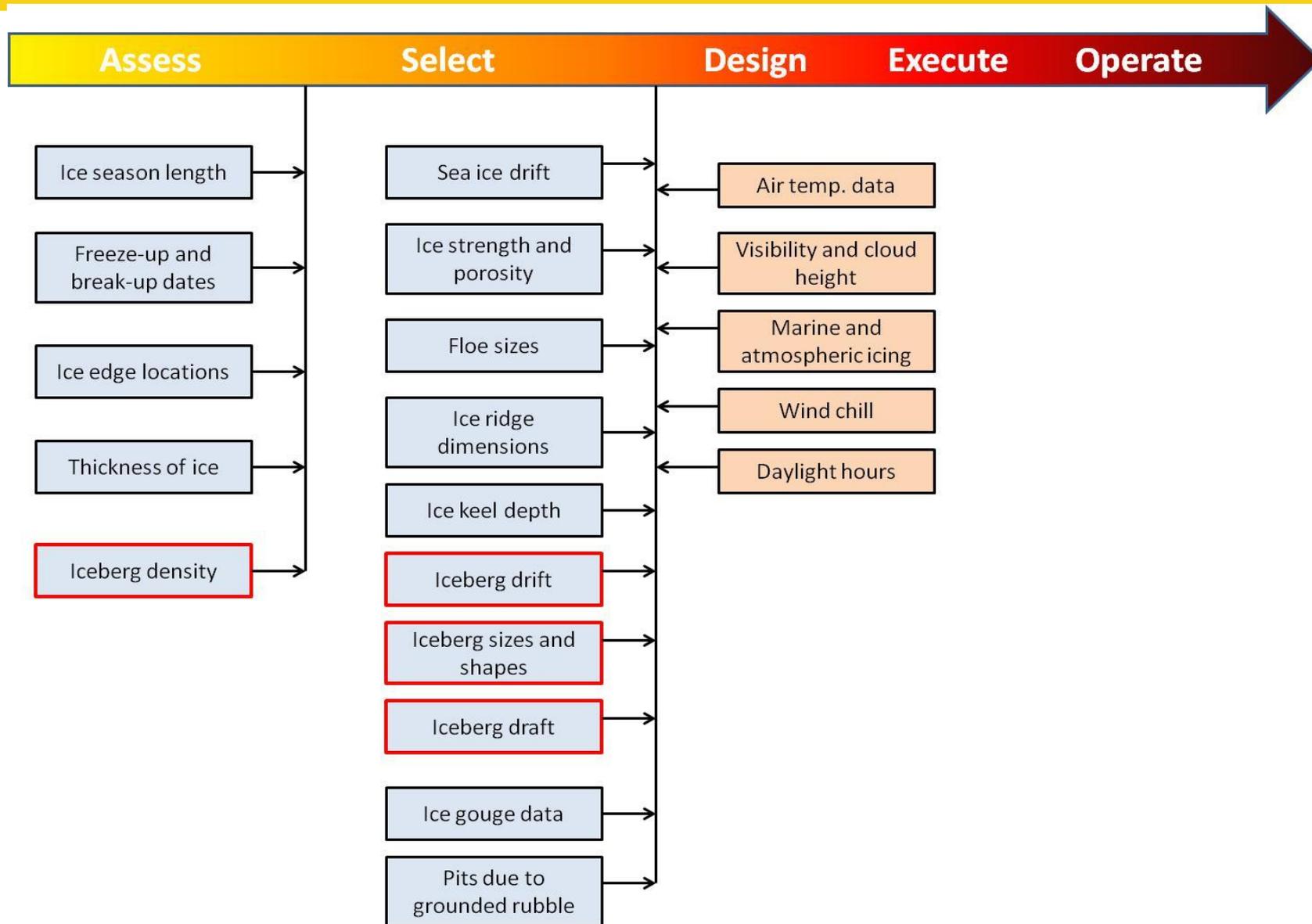
Annotation of a SAR satellite image

A CHART FOR ICE EXPERTS– TO BE STORED IN A DATABASE



Ice chart with ice eggs + locations of stamukhi

ICE DATA NEEDED FOR ENGINEERING



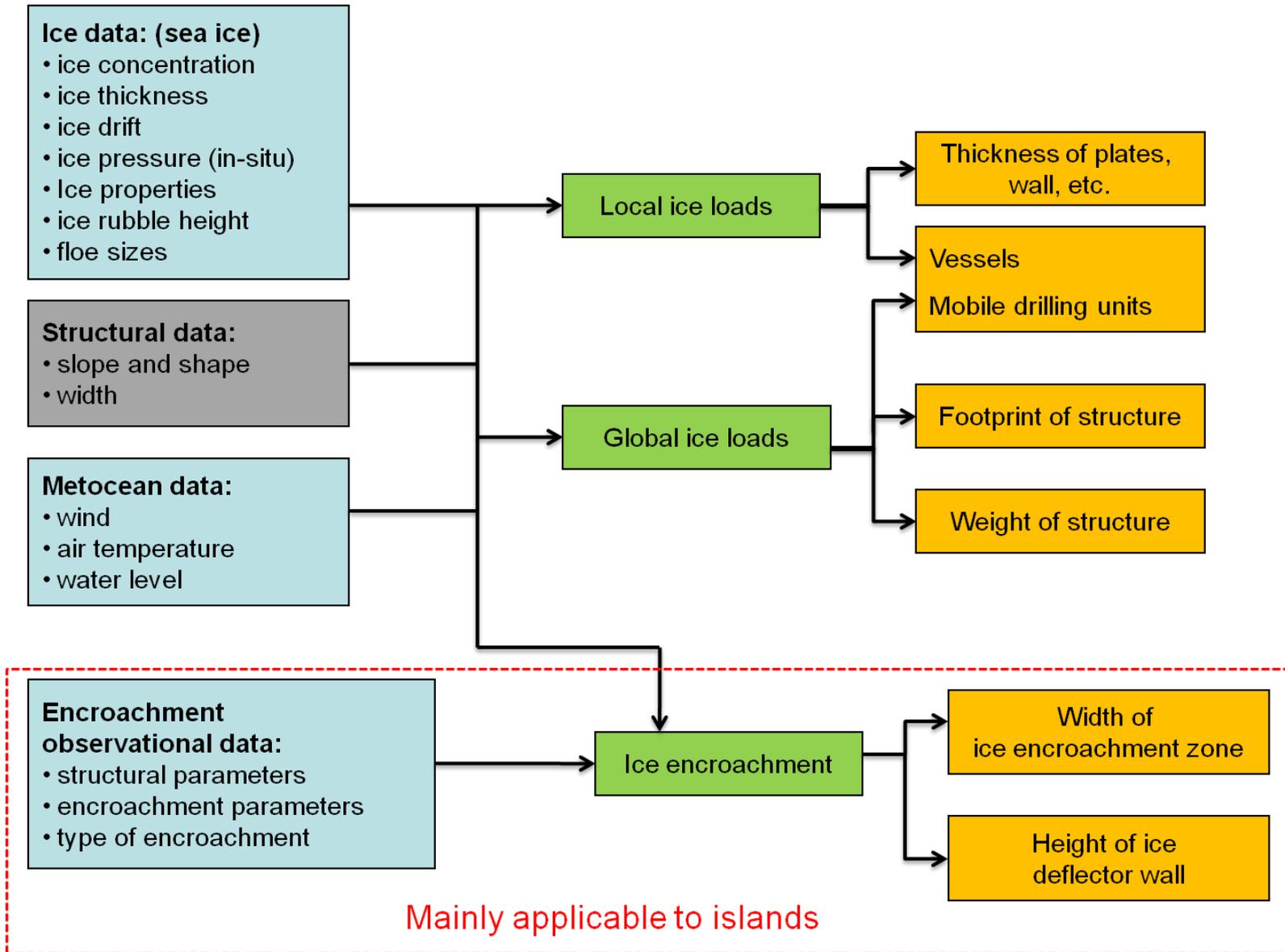
EXAMPLE : MARINE ICING



Views of the marine icing accumulations that formed on the Molikpaq and its topsides during an extreme storm event in early December 2002



ICE DATA FOR DESIGN OF STRUCTURES



LOADS ON FIXED STRUCTURES

The ice environment

- ice sheet
- ice ridge
- iceberg
- FY vs. MY ice

Limits to loads

- Limit Stress
- Limit Force
- Limit Energy

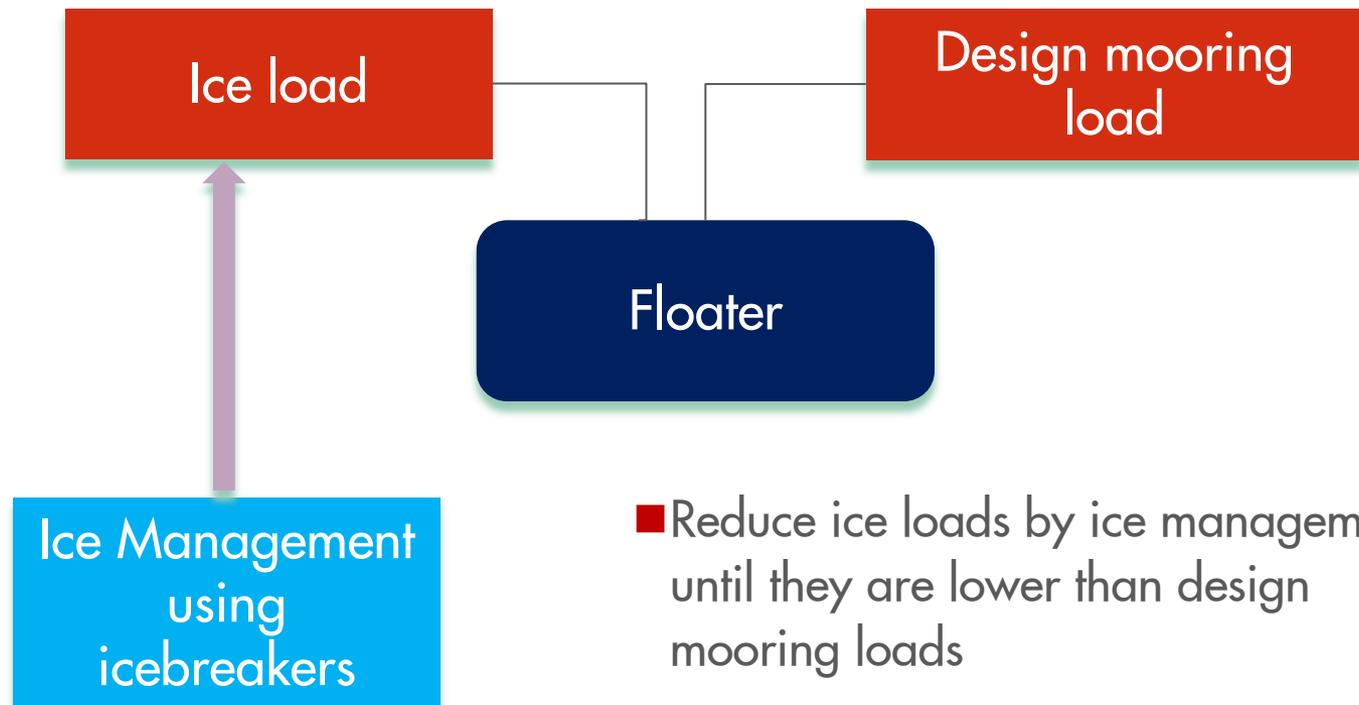
The dimensions of the structure

- Sloping or vertical face
- Width of the structure
- Overall shape

Ice load

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graph LR; A["The ice environment"] --> D["Ice load"]; B["Limits to loads"] --> D; C["The dimensions of the structure"] --> D;
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LOADS ON FLOATING STRUCTURES

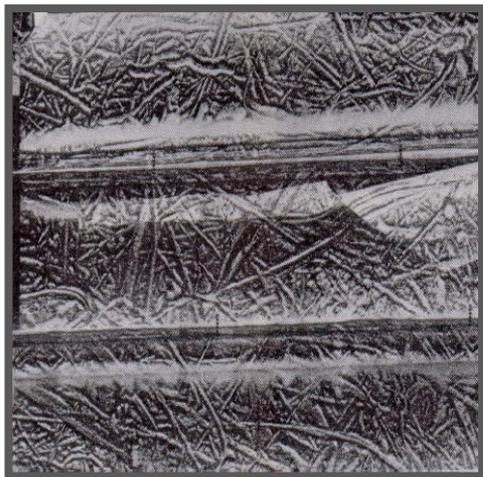


- Reduce ice loads by ice management until they are lower than design mooring loads
- Ice management will reduce floe sizes and confinement of the ice

ICE-PIPELINE INTERACTION: GOUGES AND PITS

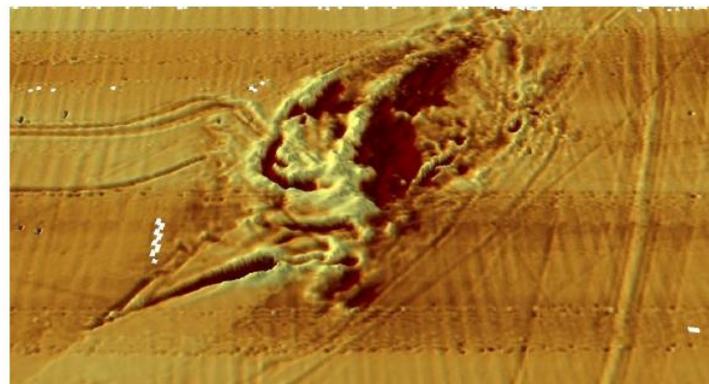
Ice gouges

- Mainly linear features observed on the seabed
- Caused by moving ice features

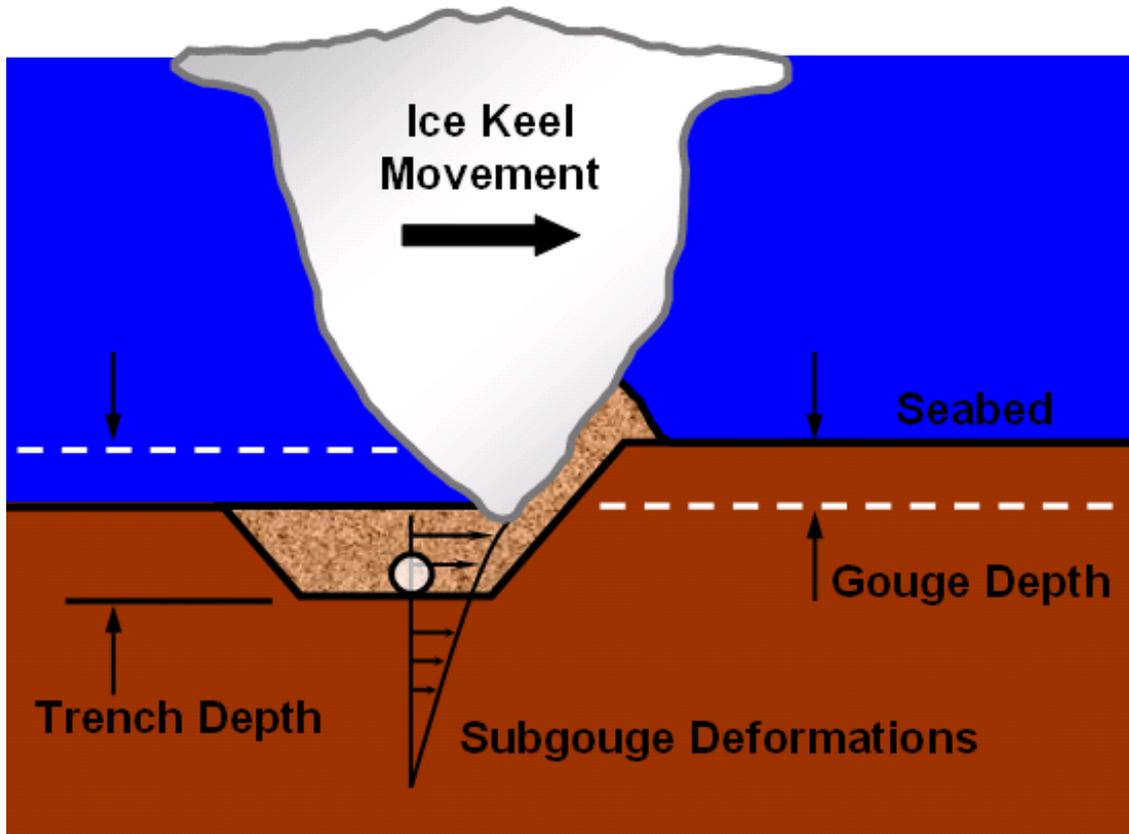


Pits

- Circular features
- Caused by heavily grounded stationary ice rubble (stamukha)
- Stamukha may change and start moving



PIPELINES - THE ICE GOUGE PROBLEM



- Direct contact between ice and pipe should be avoided
- Soil is displaced below the gouging keel as well
- Displacements at pipe depth must be sufficiently small to limit strains in pipe

ICE DATA FOR PIPELINES

