Russian Space Infrastructure applied in the Arctic: sea ice application within Roshydromet

Vasily Smolyanitsky
Arctic and Antarctic Research Institute (AARI)

Vladimir Krovyotyntsev
Planeta Research Center for Space Hydrometeorology
Satellite sea ice applications:

• **Operative tasks:**
  – 24/7 sea ice operative analysis & monitoring
  – Sea ice charting
  – General and customized hydrometeorological services (support)

• **Climatic monitoring of sea ice parameters**
  – Sea ice boundary, extent, MYI variability
  – Long-term planning and informing of federal bodies

• **Research applications**
  – NP and other field activities support
  – development of algorithms for Arctic sea & land ice, atmosphere and ocean monitoring
Institutions:

Arctic and Antarctic Research Institute (AARI): http://www.aari.ru

Planeta Research Center for Space Hydrometeorology: http://planet.iitp.ru
Ice-covered regions operationally monitored by AARI

Arctic Ocean and shelf seas: 1-7 days periodicity

Antarctic sectoral analysis on bi-weekly scale
**Keypoints:**
- from 1992 satellite imagery is the prime source of initial data for sea ice parameters
- satellite imagery wherever possible is complemented by ground-truth obs from ships, drifting platforms and coastal stations
- analysis is validated upon history
- multi-sensor approach is always used

<table>
<thead>
<tr>
<th>Imagery</th>
<th>Approx no. scenes per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radarsat</td>
<td>Infrequently, in winter season 30-50</td>
</tr>
<tr>
<td>Envisat</td>
<td>30 GMM/WSM</td>
</tr>
<tr>
<td>MODIS</td>
<td>300</td>
</tr>
<tr>
<td>AVHRR</td>
<td>450</td>
</tr>
<tr>
<td>SSM/I, AMSR</td>
<td>approx 30 per month</td>
</tr>
<tr>
<td>QuikScat</td>
<td>approx 30 per month</td>
</tr>
</tbody>
</table>
Services provided by the AARI:

- **Service 1:** navigation support to shipping – repetitive coverage in areas and sections that change seasonally (daily...weekly imagery, analysis and prognostic ice charts)
- **Service 2:** routine monitoring of Eurasian Arctic & other Russian ice covered waters and Antarctic to produce weekly and be-weekly analysis of ice conditions
- **Service 3:** tailored support for offshore activities in points (daily...weekly charts and imagery)
- **Service 4:** infrequent spot coverage in response to specific incident
- **Service 5:** infrequent spot coverage in response to tourist activities
Services are provided within the NSR and new IHO/WMO NAVAREAS/METAREAS

1 general and 4 destination or customer-oriented services

Bulker “Noril’skii Nickel”, ice class LA7: new ice class, several built, bow in open water, stern in ice
Main satellite communication facilities in the western sector of NSR
AARI operational satellite based ice products

NOAA

MODIS

ENVISAT SAR WSM

Data assimilation and ice forecast

Ice chart
Northern Sea Route in August – September 2009

2-4 August
9-11 August
16-18 August

23-25 August
30 Aug – 1 Sep
6 – 8 September

13 – 15 Sep
20 – 22 Sep
27 – 29 Sep
Arctic sea ice conditions – monitoring from 1933...2009 (charts)

Robust mean sea ice total concentration in September

5% quantile sea ice total concentration in September

Ice chart for 16-19 Sep'07

Ice chart for 15-17 Sep'08

Ice chart for 13-15 Sep'09
Daily estimates of the Southern Hemisphere ice extent based on NSIDC NRT SSMR-SSM/I NASATEAM algorithm total concentration patterns
3 Main centers:
Europe  
(Moscow-Obninsk-Dolgoprudny)
Siberia  
(Novosibirsk)
Far-East  
(Khabarovsk)

- 68 Local centers
Multiyear Arctic ice dynamics in the western part of Arctic

(OKEAN satellite, side-looking radar, 1.5 – 2 km, December 1983-1999,
QuikSCAT satellite, Sea Wind NRT, 35–40 km, December 2002-2008)
Planeta Automated classification ice objects in multispectral satellite data.

Cluster analysis

Recognizing method definition

Test polygons choosing

Classification and result smoothing
Planeta ice drift maps creation

1. Searching for etalons in the current image and in the next time step image

2. Searching for optimal vector

3. Object drift map creation

4. Creation of the objects drift maps and wind speed and direction diagrams
AARI North Pole drifting station logistics support

1) Search for potential objects
   Multi-sensor approach
   Envisat WSM, MODIS, Landsat
North Pole drifting station logistics support

2) Tracking origin
North Pole drifting station logistics support

3) Deployment and support during life cycle
## Russian Earth Observation Satellites Program

### 2006-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Geostationary meteorological system</th>
<th>Polar-orbiting meteorological system</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **ELECTRO № 1 (76°E)**
- **ELECTRO № 2 (location TBD)**
- **ELECTRO № 3 (76°E)**
- **METEOR № 1**
- **METEOR № 2**
- **METEOR № 3 (Oceanographical)**
- **METEOR № 4**
- **METEOR № 5**
- **METEOR № 6 (Oceanographical)**
Russia had launched a new meteorological satellite on board a Soyuz 2.

**General characteristics “Meteor-M” №1:**
- **Launch date:** 17 September 2009
- **In-orbit mass:** ~2700 kg
- **Payload mass:** ~1200 kg
- **Lifetime:** 5 years
- **Data dissemination format:** HRPT, LRPT

**Orbit parameters:**
- **Orbit:** Sun synchronous (near polar)
- **Altitude:** 830 km
- **Period:** 101.45 min
- **Inclination:** 98.72°
- **Time of equator crossing (descending):** 9:30 a.m.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Application</th>
<th>Spectral Band</th>
<th>Swath-width (km)</th>
<th>Resolution (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSU-MR multi-channel scanner for meteorological purposes</td>
<td>Global and regional cloud cover mapping, SST, LST, ...</td>
<td>0.5 – 12.5 μm (6 channels)</td>
<td>3000</td>
<td>1 x 1</td>
</tr>
<tr>
<td>KMSS multi-channel Earth surface observation complex</td>
<td>Earth surface monitoring</td>
<td>0.4-0.9 μm (6 channels)</td>
<td>400</td>
<td>0.06/0.1</td>
</tr>
<tr>
<td>MTVZA atmosphere temperature and humidity sounding module</td>
<td>Atmospheric temperature and humidity profiles, sea surface wind</td>
<td>10.6-183.3 GHz (26 channels)</td>
<td>2600</td>
<td>12 – 75</td>
</tr>
<tr>
<td>IRFS-2 advanced IR sounder (Meteor-M №2)</td>
<td>Atmospheric temperature and humidity profiles</td>
<td>5-15 μm</td>
<td>2000</td>
<td>35</td>
</tr>
<tr>
<td>Severjanin (SAR) synthesized aperture radar</td>
<td>Ice monitoring</td>
<td>9500-9700 MHz</td>
<td>450</td>
<td>0.4 x 0.5</td>
</tr>
<tr>
<td>GGAK-M helio-geophysical complex</td>
<td>Near-Earth space environment monitoring</td>
<td>Helio-geophysical complex is designed for analysis of the following parameters: electron flux density with 0.03 - 15.0 megaelectron-volt energy; proton flux density with 0.5 - 30.0 megaelectron-volt energy; ions concentration in the upper atmosphere in range 1-20 atomic mass units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The satellite is also capable of acquiring information from ground data collection platforms using international frequency band (401.9 - 402.0 MHz) at 400 bit/sec rate.
Sample false color images from KMSS instrument for Sep-Oct’09

<table>
<thead>
<tr>
<th>KMSS multichannel scanning unit</th>
<th>channel</th>
<th>swath</th>
<th>resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.370-0.450 мкм</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.450-0.510 мкм</td>
<td>450, 900 км</td>
<td>60 м/100 м</td>
</tr>
<tr>
<td></td>
<td>0.535-0.575 мкм</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.580-0.690 мкм</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.630-0.680 мкм</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.760-0.900 мкм</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sample global data received from the Meteor-M №1 MTVZA microwave scanning unit

- 10,6 GHz – data on sea surface temperature
- 18,7 GHz – data on water vapor content in the atmosphere over the sea surface and module of surface wind
- 36,7 GHz – data on integral water vapor content over the sea surface and module of surface wind
- 183 GHz – data on water vapor content in the troposphere
ELECTRO-L General Design

- Three-axis high-precision stabilization
- In-orbit mass - 1500 kg
- Payload mass - 370 kg
- Lifetime - 10 years
- Longitude - 76E
- Data dissemination format - HRIT/LRIT
- Image repeat cycle – 30/15 min

Mission objectives
- Operational observation of the atmosphere and the Earth surface (MSU-GS)
- Heliogeophysical measurements
- Maintaining Data Collection System and COSPAS/SARSAT Service
High-elliptical Orbits Satellite System "Arctica"
Perspectives of Russian satellite sea ice applications:

- Wider and more timely (1-6 hours) access to multi-sensor data, in particular dual polarization radar (within national and international agreements)
- More timely and wider-band relay of products to customers (Iridium, HFAX, Inmarsat)
- Development of standards and formats for ice charts and imagery presentation and delivery for new generation of marine and MSS systems (ENC, GMDSS, within WMO/IHO)
- Closer and further level cooperation (and harmonization) between Russian and international ice services towards seamless ice products and services within the polar Arctic and Antarctic METAREAS within WMO, IICWG, EIS etc
Perspectives of Russian satellite sea ice applications:

- Organization of training facilities for navigators and other customers for proper interpretation of ice charts and imagery
- Organization of feedback between customer at sea and provider (AARI, Planeta) (we shall know when, what and how much information was received and used by the customer)
- Extension of a list of provided information in a part of more efficient usage of satellite information with full ground resolution and regular request and reception of radar imagery
- Development of the new algorithms and techniques of satellite-based products creation and assimilation including ice charts, into numerical models
- Implementation of the next generation Russian satellite system including HEO Arctica system
Thank you for attention and questions?