# MONITORING WINTER MARINE WEATHER SYSTEMS USING SATELLITE MULTISENSOR OBSERVATIONS AND GROUND-BASED DATA

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## 1. INTRODUCTION

Satellite and *in situ* data were examined for insights into the behavior of water vapor, cloud liquid water and wind speed during formation and evolution of weather systems such as synoptic-scale and mesoscale cyclones and cold air outbreaks. They are usually accompanied by gale winds and intensive air-sea interaction. *In situ* measurements are too sparse and the spatial resolutions of numerical models are too coarse to catch even intensive small marine storms seriously disturbing transport and fishery operation at the sea due to high waves, sea ice drift, ship icing etc. It is evident from a comparison of the surface analysis charts with satellite data. Mesocyclones present a limitation to successful weather forecasting over the Arctic seas and especially over coastal Chile, southern Australia and South Africa. Total water vapor content $V$, total cloud liquid water content $Q$ and sea surface wind velocity $W$ have been estimated from the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) of Aqua, from the QuikSCAT scatterometer and occasionally from Envisat ASAR. $V$ and $W$ values were have also been estimated using humidity profiles and wind measurements provided by radiosonde stations, oceanic buoys and the NCEP/NCAP reanalysis as well as by the AMSR-E brightness temperatures $T_B^{V,H}$ at frequency of $\nu = 89$ GHz with vertical (V) and horizontal (H) polarization. Instant field of view of 89 GHz channels is approximately 4 km x 6 km [1]. Visible and infrared data on cloud fields were provided by MODIS spectroradiometer from Terra and Aqua and NOAA AVHRR.

## 2. DATA

Aqua AMSR-E, QuikSCAT SeaWinds, Envisat ASAR and ALOS PALSAR data acquired over the Northern Pacific and Atlantic Oceans in winter seasons of 2002-2009 have been analyzed. Data were downloaded from several Internet web sites and were also obtained from the Japan Aerospace Exploration Agency (JAXA) and the European Space Agency (ESA). Intense synoptic-scale and mesoscale weather systems with storm winds were selected for detailed study based on the usage of multisatellite/multisensor and *in situ* data. Various satellite sensors possess by the spatial resolution ranged from several tens meters – several hundred meters (Envisat ASAR, ALOS PALSAR, Terra and Aqua MODIS) to one kilometer – several tens kilometers (NOAA AVHRR, MODIS, Aqua AMSR-E) that allow to detect and investigate both the large-scale structural features such as the main and the secondary fronts and the small and fine scale details of the frontal boundaries, organized convection in the marine boundary layer of the atmosphere, etc. as well as to reveal the location and structure of the ice edge and the marginal ice zone. Multisatellite approach improves temporal resolution and the possibility to trace the location and characteristics of weather systems that has a special importance for fast moving and fast evolving systems.

## 3. RESULTS

The results presented were focused on the changes of $V$, $Q$ and $W$ during origin, movement and dissipation of marine weather systems occurring over the Okhotsk and Bering Seas and over the Northern Atlantic Ocean during the cold seasons 2005-2009. Several algorithms for $V$, $Q$ and $W$ retrieval were designed using the simulated brightness temperatures $T_B^{V,H}(\nu)$ at AMSR-E frequencies $\nu$ with vertical (V) and horizontal (H) polarization. These algorithms are physically-based and were tested for the various climatic zones. $T_B^{V,H}$ at $\nu = 23.8$ and 36.5 GHz with V-polarization were used to retrieve $V$ and $Q$ with root-mean square of 1-2 kg/m$^2$ [2]. Retrieval errors of Neural-Network-based algorithms were lower that follows both from the results of modeling and from a comparison of the retrieved $V$-values with radiosonde data [3]. Wind fields were derived from QuikSCAT data and also from the measured $T_B^H$ at $\nu = 10.7$ GHz after correction, the value of which depends on $V$ and $Q$.

A mesocyclone of the size of 150-200 km located over the Northern Okhotsk Sea near cold land and the sea ice has been formed in a low level trough elongated from a deep cyclone centered to the south of Kamchatka. It was clearly expressed in fields of cloudiness, brightness temperatures and surface wind measured by MODIS, AMSR-E, SeaWinds and ASAR, correspondingly (Figure 1). Sharp boundary of surface wind shift is clearly distinguished. A bright narrow convective band and positive $T_B$s increments correspond to this boundary. Northeastern wind speed to the north of the band is 12-16 m/s. Weak winds are observed in the center of mesocyclone. Small dark zone marks the center on ASAR image. Tight correspondence between location of cloud bands, wind speed and total atmospheric water vapor content is evident from analysis of Figure 1a-e taking into account time difference in sensing from different satellites.

Cold air outbreaks were investigated over the Eastern Bering Sea where there are oceanic buoys and radiosonde station. Sharp gradients of surface wind velocity, the wave-like and eddy-like features along the atmospheric fronts were detected on SAR images in the mesocyclone

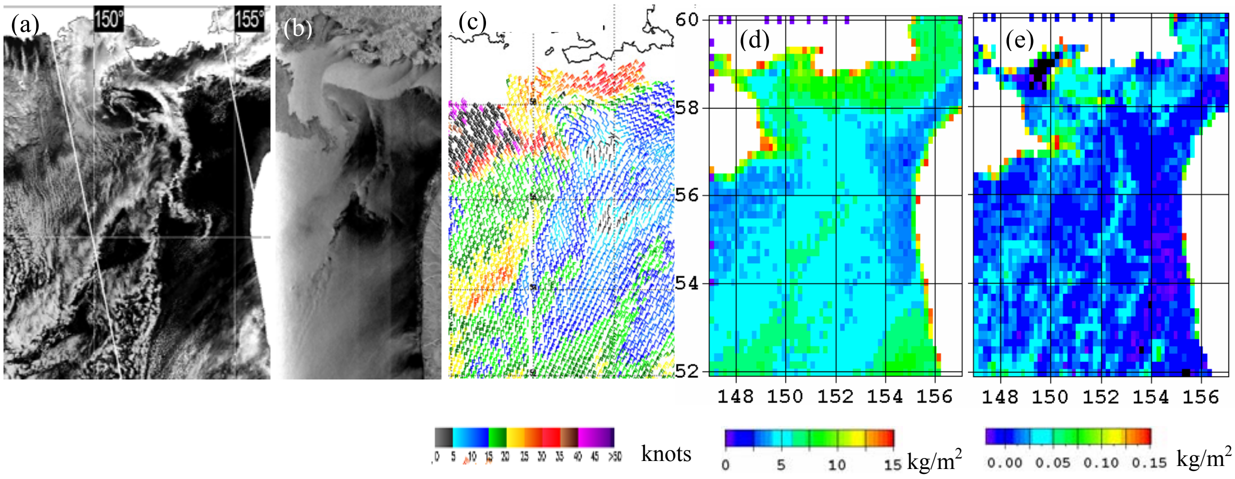


Figure 1. Mesoscale cyclone over the Okhotsk Sea on 29 Dec 2006: (a) AVHRR IR image at 11:16 UTC, (b) ASAR image at 11:23 UTC, (c) QuikSCAT-derivied wind field at 07:44 UTC, (d) AMSR-E-derived total water vapor and (e) total cloud liquid water at 16:30 UTC.

regions. Mesocyclones are "dry" weather systems with low values of total cloud liquid water content. Typical *V*-values are 3-8 kg/m$^2$ and typical *Q*-values did not exceed 0.15-0.2 kg/m$^2$. The *V*-values were increased downstream from the land or ice boundary. The values of *Q* were estimated for the individual convective rolls and cells by joint analysis of $T_B$ at 89.0, 36.5 and 23.8 GHz. Zones of precipitation (rain and/or snow) were detected by analysis of $T_B(89)$ fields at V- and H-polarization.

The large group of mesoscale cyclones occurring in the Polar Regions is referred to as polar cyclones. An example of polar low in the Greenland Sea on 24 January 2008, manifesting itself in the fields of wind, water vapor and cloud liquid water, is shown in Figure 2.

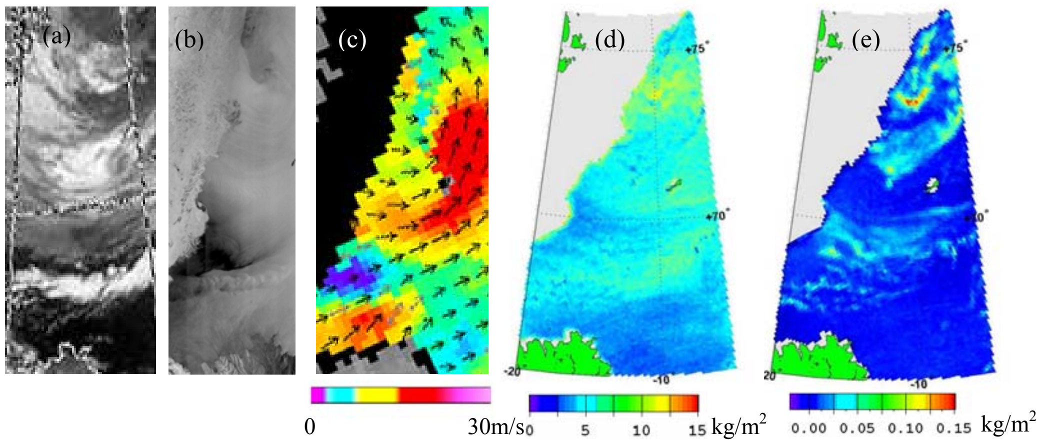


Figure 2. Polar low over the Greenland Sea on 24 January 2008: (a) AVHRR IR image at 12:52 UTC, (b) ASAR image at 11:50 UTC, (c) QuikSCAT-derived wind field at 18:50 UTC, (d) AMSR-E-derived total water vapor and (e) total cloud liquid water content at 12:20 UTC.

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## 4. REFERENCES

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