AMSR-E ADVANCED WIND SPEED RETRIEVAL ALGORITHM

AND ITS APPLICATION TO MARINE WEATHER SYSTEMS

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1. INTRODUCTION

Information about sea surface wind is necessary for operational activity, computation of waves, study air-sea interaction, etc. Space-borne microwave sensors are used to retrieve wind speed and direction (QuikSCAT and MeTOP scatterometers) or only wind speed W (SSM/I, TMI and AMSR-E radiometers). Wind speed retrieval was carried out using the brightness temperatures T_Bs measured both at high-frequency (37 GHz) [1, 2] and low-frequency (6.6 and 10.7 GHz) [3] microwave channels. Physical-based, linear and non-linear statistical algorithms including Neural-Network-based ones were developed for SSM/I and AMSR-E data processing. Heavy clouds and rains prevent wind speed retrieval from T_Bs at frequency $\nu = 37$ GHz. Atmospheric attenuation at $\nu = 6.6$ and 10.7 GHz is significantly less and wind speed W may be estimated even at heavy clouds and rain, however, at lower spatial resolution. In this paper, a physical-based wind speed retrieval algorithm is considered. In some respect, it is modification and advancement of algorithm [3], however, without the usage of 6.6 GHz channel with horizontal (H) polarization. W retrieval is carried out with the use of the AMSR-E brightness temperatures T_B(11H) at 10.7 GHz, T_B(24V) at 23.8 GHz and T_B(36V) at 36.5 GHz with vertical (V) polarization. The T_B(24V) and T_B(36V) serve to retrieve total cloud absorption $\tau_{cl}(11)$ and total atmospheric water vapor content V. In turn, $\tau_{cl}(11)$ and V values allow to determine contribution of atmospheric emission to T_B(11H) and estimate the brightness temperature of the ocean T_{Boc}(11H). Finally, wind speed is determined from the difference between this estimate and the T_{Boc}(11H) computed at $W = 0$ m/s. Wind fields in intense winter extratropical cyclones retrieved with the suggested algorithm are considered and compared with QuikSCAT-derived wind fields.

2. ALGORITHM

Algebraic form of the radiative transfer equation can be written as [3]:

$$T_B^{V,H}(\nu,\theta,t_o,W) = \chi^{V,H}(\nu,\theta,t_o,W)\cdot T_o\cdot e^{-\tau(\nu)\sec\theta} + T^{\uparrow}_{я}(\nu,\theta) + T^{\downarrow}_{я}(\nu,\theta)\,[1-\chi^{v,h}(\nu,\theta,t_o,W)]\,e^{-\tau(\nu)\sec\theta} +$$
$$T_{\cos}[1-\chi^{v,h}(\nu,\theta,t_o,W)]\cdot e^{-2\tau(\nu)\sec\theta}, \qquad (1)$$

where $T_B^{v,h}(\nu,\theta,t_o,W)$ is the brightness temperature of the ocean-atmosphere system, θ is incidence angle; t_o is the sea surface temperature; $\chi^{V,H}(\nu,\theta,t_o,W)$ is the emissivity of the sea surface at V and H polarization; $T_o = t_o + 273{,}16$; $\tau(\nu)$ is the total atmospheric absorption; $T^{\uparrow}_B(\nu,\theta)$ and $T^{\downarrow}_B(\nu,\theta)$ are the upwelling and downwelling brightness temperatures of the atmosphere, respectively; $T_{cos} = 2{,}7$ K is the brightness temperatures of the cosmic background radiation.

Consider the brightness temperature at 10.7 GHz with H polarization for AMSR-E sensing geometry (θ = 55°). Wind speed can be derived from the first term of equation (1) $\chi^H(11,t_o,W)\cdot T_o\cdot e^{-\tau(11)\sec 55} = T_{Boc}(11H)$, if t_o and the total atmospheric absorption τ(11) are known. τ(11) consists of molecular oxygen absorption $\tau_{ox}(11) \approx 0.01$, water vapor absorption $\tau_{wv}(11) = a_{wv}(11)V$, where V is the total atmospheric water vapor content and $a_{wv}(11)$ is a known coefficient, and cloud $\tau_{cl}(11)$ absorption. Cloud and water vapor absorptions can be estimated from $T_B(24V)$ and $T_B(36V)$ using algorithm [4] allowing to derive two parameters: V and $\tau_{cl}(36)$ associated with $\tau_{cl}(11)$ by the relationship: $\tau_{cl}(11) = R(t_{cl})\tau_{cl}(36)$, where t_{cl} is the effective cloud temperature. $R(t_{cl})$ is well approximated by a quadratic function:

$$R(t_{cl}) = 0.0953 - 0.00056\, t_{cl} + 1.088\, t_{cl}^2$$

In turn, t_{cl} can be assumed as $t_o - \Delta t_o$, where Δt_o = 10-15°C are typical values.

Thus $\tau(11) = 0.01 + a_{wv}(11)V + R(t_{cl})\tau_{cl}(36)$ that allows to determine both atmospheric and oceanic components of the measured brightness temperature $T_B^H(11,t_o,W)$. Atmospheric components $T^{\uparrow}_B(11)$ и $T^{\downarrow}_B(11)$ can be written as

$$T^{\uparrow}_B(11) = [T_{air} - \Delta T^{\uparrow}(11)]\cdot[1 - e^{-\tau(11)\sec 55}]$$

$$T^{\downarrow}_B(11) = [T_{air} - \Delta T^{\downarrow}(11)]\cdot[1 - e^{-\tau(\nu)\sec 55}], \qquad (2)$$

where T_{air} is surface air temperature, $\Delta T^{\uparrow}(11)$ и $\Delta T^{\downarrow}(11)$ are the corrections for nonisothermity of the atmosphere, which can be calculated assuming that $T_{air} = T_o$ and $\Delta T^{\uparrow}(11) = \Delta T^{\downarrow}(11)$ [4].

The forth term in equation (1) characterizing contribution of cosmic background radiation to $T_B^H(11,t_o,W)$ can be estimated using the atmospheric absorption and emissivity values. This term is equal approximately to 2 K.

The brightness temperature of the calm ocean surface $T_{Boc}(11H, W{=}0) = \chi^H(11,t_o,W{=}0)\cdot T_o\cdot$as a function of t_o is computed using the values of the sea surface emissivity found with the Fresnel equation and the sea water dielectric permittivity [5].

An example of wind field retrieval in extratropical cyclone with hurricane winds which was observed over the Northwest Pacific Ocean on 19 November 2009 is considered. AMSR-E retrieved wind fields at 01:25 and at 14:55 UTC are shown in Fig. 1. These fields agree with QuikSCAT-derived winds at 07:29 and at 17:14 UTC (Fig. 2). Data obtained by two sensors improve time resolution.

3. WIND FIELD IN EXTRATROPICAL CYCLONE

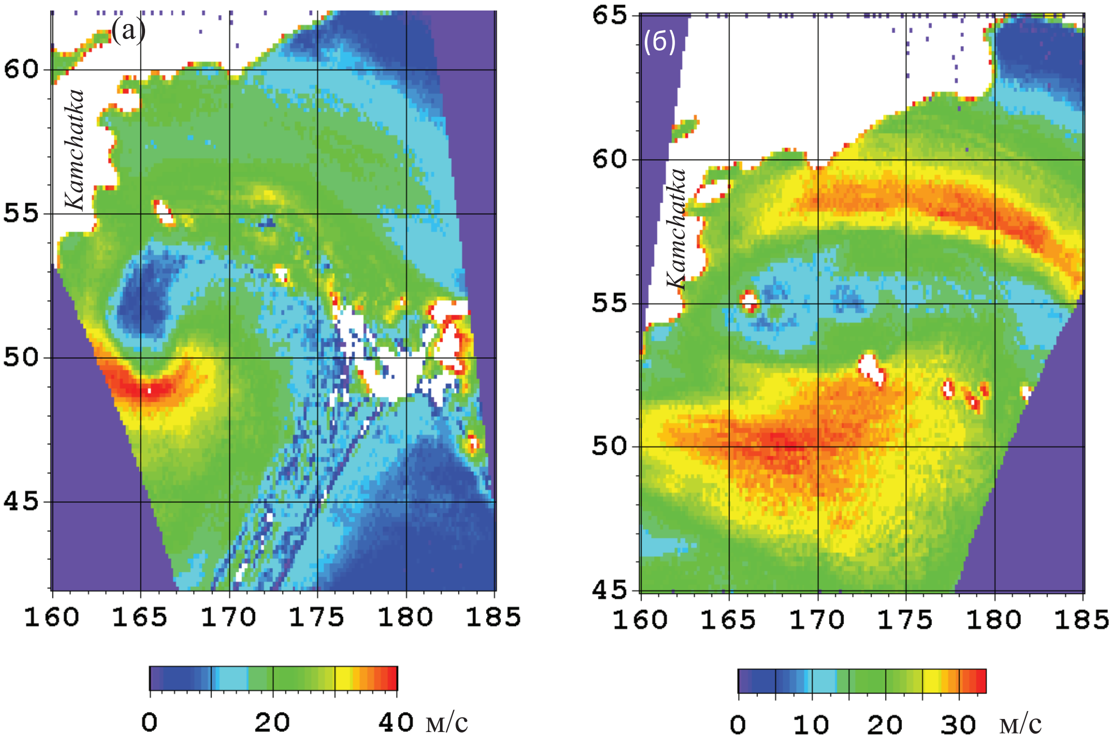

Fig. 1. AMSR-E-derived wind fields over the Northwest Pacific Ocean on 19 November 2009 at 01:25 UTC (a) and at 14:55 UTC (b)

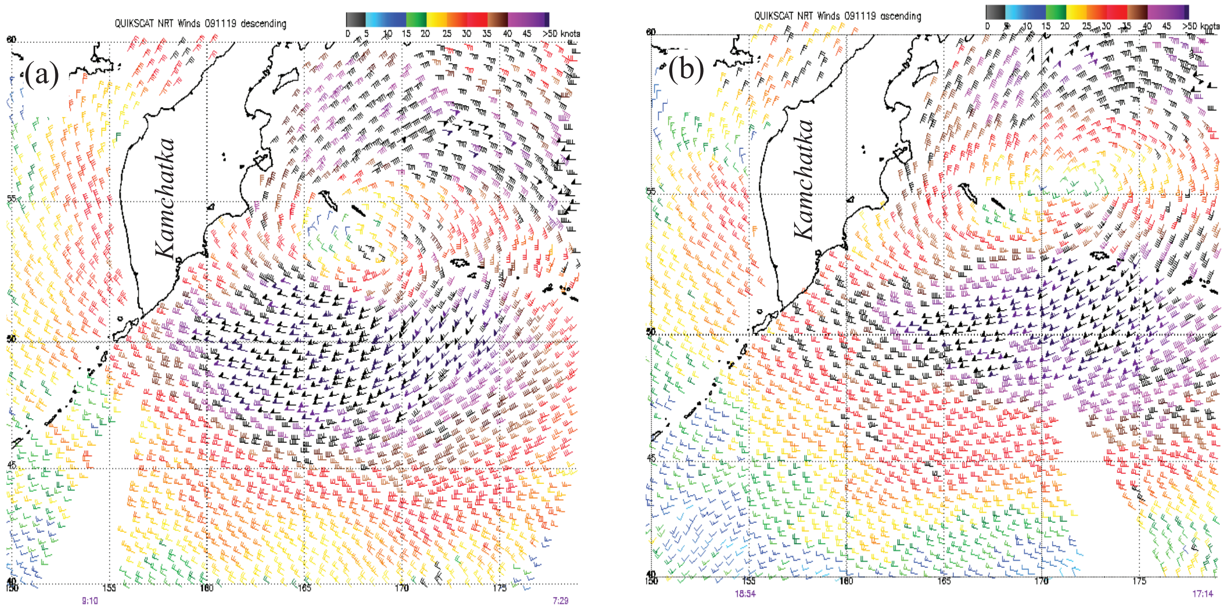

Fig. 2. QuikSCAT-derived wind field over the Northwest Pacific Ocean on 19 November 2009 at 07:29 UTC (a) and at 17:14 UTC (b).

4. REFERENCES

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