



## Tracking the complete revolution of surface westerlies over Northern Hemisphere using radionuclides emitted from Fukushima

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### HIGHLIGHTS

- ▶ Evidence of the South Korea contamination with released radiocesium from Fukushima.
- ▶ Field samples and air mass analysis were utilized to elucidate the transport of those radionuclides.
- ▶ Characterization of the air mass movements at different sites at the Earth's surface.
- ▶ Verification of the uninterrupted complete revolution of the artificial radionuclides released in Fukushima.
- ▶ Quantification of the velocity of the artificial radionuclides released in Fukushima.

### ARTICLE INFO

#### Article history:

Received 17 April 2012

Received in revised form 13 July 2012

Accepted 6 August 2012

Available online 10 September 2012

#### Keywords:

Fukushima

<sup>134</sup>Cs

Atmosphere

Air masses

Westerlies

Northern Hemisphere

### ABSTRACT

Massive amounts of anthropogenic radionuclides were released from the nuclear reactors located in Fukushima (northeastern Japan) between 12 and 16 March 2011 following the earthquake and tsunami. Ground level air radioactivity was monitored around the globe immediately after the Fukushima accident. This global effort provided a unique opportunity to trace the surface air mass movement at different sites in the Northern Hemisphere. Based on surface air radioactivity measurements around the globe and the air mass backward trajectory analysis of the Fukushima radioactive plume at various places in the Northern Hemisphere by employing the Hybrid Single-Particle Lagrangian Integrated Trajectory model, we show for the first time, that the uninterrupted complete revolution of the mid-latitude Surface Westerlies took place in less than 21 days, with an average zonal velocity of >60 km/h. The position and circulation time scale of Surface Westerlies are of wide interest to a large number of global researchers including meteorologists, atmospheric researchers and global climate modellers.

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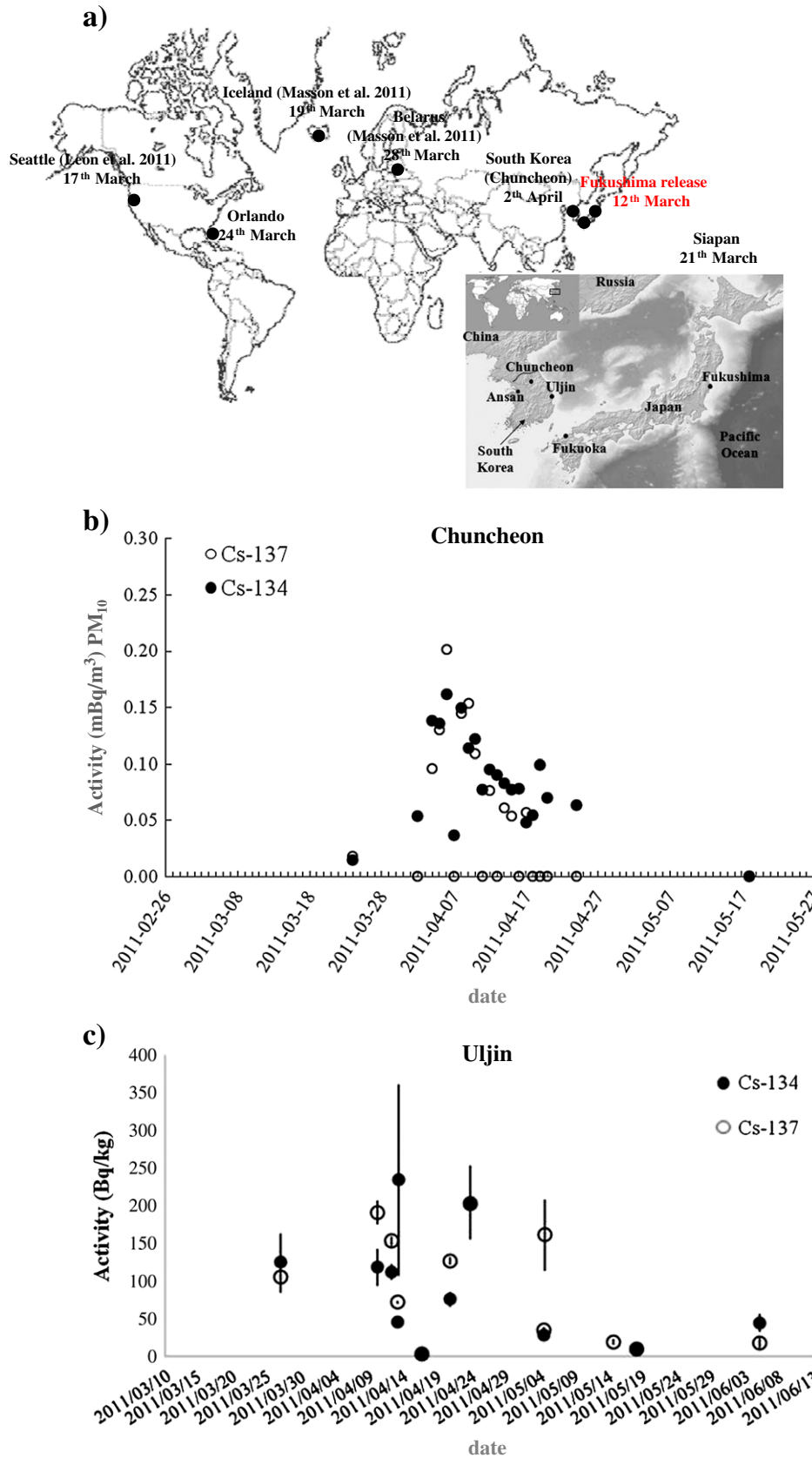
### 1. Introduction

Surface westerlies are a dominant feature in the mid-latitudes of the Northern Hemisphere throughout the year. The speed of the westerlies increases from the land or sea surface to higher altitudes because of a strong temperature gradient in the meridional direction in the mid-latitudes. Meteorological measurements and analysis of climate data can be used to calculate wind fields and back trajectories of air parcels by running atmospheric models in reverse to determine the wind fields resulting from synoptic conditions, and hence the

general source of, and path taken by, an air mass that crossed a given region of interest. Various tracers of natural and man-made materials (e.g., sulphur isotopes, metals, radionuclides) have been used to verify the meteorological models in recent decades. Trade wind circulation in the lower latitude was successfully traced earlier based on the dispersal of radionuclides emitted from the nuclear weapon tests at or near the earth's surface near the equator in 1952 and 1954 (Machta et al., 1956). The high altitude westerlies in the mid-latitudes over the Northern Hemisphere were also successfully traced by the presence of Asian dust originated from the central Asia (~40°N, 88°E) embedded in the glaciers of Greenland and French Alps as well as the bottom of the North Pacific Ocean (Steffensen et al., 2008; Uno et al., 2009). However, surface westerlies travel mostly in the lower troposphere and are often disrupted due to the uneven distribution of synoptic scale atmospheric pressure systems; therefore more than

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**Fig. 1.** (a) First arrival date of Fukushima radioactive substances at various sites in the northern Hemisphere. (b) Atmospheric aerosol concentration of <sup>134</sup>Cs and <sup>137</sup>Cs in Chuncheon, South Korea (data from Korea Institute of Nuclear Safety website). The aerosol was collected at 09:00 am every morning for the next 24 hours on to a glass fiber filter using a high volume sampler (Kim et al., 2011). (c) <sup>134</sup>Cs and <sup>137</sup>Cs activity concentration in dust falling on the ground during March to June 2011 in Uljin, Korea. Error bars arise from 1- sigma counting statistics.

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