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CHAPTER 1. INTRODUCTION

1.1 HISTORICAL PERSPECTIVE

On 1 April 1960, a new era started for meteorology with the launch of the Television and Infrared Observation Satellite – 1 (TIROS-1). Weather systems, which had only been depicted until then by synoptic maps and aircraft observations, could be visualized at a glance. Their rapidly evolving nature became more evident with geostationary imagery from the Applications Technology Satellite – 1 (ATS-1), launched on 6 December 1966. The term “nowcasting” emerged, becoming the first application of meteorological satellites.

Initially, satellite data were nearly exclusively used for nowcasting. They were first applied to the field of numerical weather prediction, starting with Nimbus-3 (13 April 1969), by using data from experimental instruments to derive vertical profiles of atmospheric temperature and humidity and by deriving cloud-motion winds from geostationary image sequences.

The First Global Atmospheric Research Programme (GARP) Global Experiment (FGGE, 1979–1980) was able to assemble, for the first time, a composite system of four geostationary satellites and two near-polar satellites, which delivered global sounding and imaging coverage four times a day and imagery at low and mid latitudes every half hour. It is important to note that since their early days, in addition to supporting operational applications, meteorological satellites have enabled advances in the understanding of atmospheric dynamics and climate.

Driven by the high economic value of earth resource exploration and vegetation cycle monitoring, new satellite programmes emerged with a focus on land surface observation. Landsat-1, launched on 23 July 1972, led the first series of high-resolution land observation satellites, and coverage from the Satellite pour l’Observation de la Terre (SPOT) series, beginning on 22 February 1986 with SPOT-1, provided imagery at a spatial resolution of 10 to 20 metres.

Exploration of the ocean began with the launch of SeaSat on 27 June 1978, which marked the advent of all-weather microwave sensing, both active and passive. Almost simultaneously, on 24 October 1978, Nimbus-7 used passive microwave sensing with the addition of ocean colour monitoring. After the SeaSat altimetry, scatterometry and synthetic aperture radar imagery missions, no active sensing mission was operated until the launch of the European Remote-sensing Satellite – 1 (ERS-1) on 17 July 1991. The retrieval of information on atmospheric radiation and chemistry was initially explored by several Nimbus missions. A milestone for Earth radiation study was the Earth Radiation Budget Satellite (ERBS), launched on 5 October 1984. For atmospheric chemistry, a major milestone was the Upper Atmosphere Research Satellite (UARS), launched on 12 September 1991.

1.2 SPATIAL AND TEMPORAL SCALES

The concept of the Global Observing System was totally revised with the advent of satellites, taking advantage of the complementary nature of surface-based and space-based observations. The space-based component offers the unique opportunity of uninterrupted global coverage and frequent observing cycles. A striking advantage is the capability of vertical atmospheric sounding over the oceans, alleviating a great limitation of observations for global numerical weather prediction. Over continental areas, observing networks are biased towards populated areas, whereas the vast majority of land surfaces are relatively unpopulated and hence undersampled; furthermore, some local observations available from the ground (e.g. cloud type) are hard to integrate spatially.

One important difference between satellite and surface measurements is the integration in space and time. Satellite measurements integrate the incoming signal over an instantaneous field of view determined by the need to collect sufficient radiant energy to provide the required signal-
to-noise ratio. Surface measurements are usually point-related, although, depending on the observed variable, the measurement may be representative of a larger or smaller area. In the time dimension, the situation is reversed: satellite measurements are nearly instantaneous depending on the satellite motion or the time available to acquire a picture element (pixel) when scanning an image; surface measurements usually integrate over a certain time interval in order to average instantaneous fluctuations. These differences make it more difficult to compare or combine satellite and surface measurements.

1.3 COMPLEMENTARY NATURE OF SPACE-BASED AND SURFACE-BASED MEASUREMENTS

It is acknowledged that satellites are unable to perform all needed observations with the required measurement quality. For certain geophysical variables, no remote-sensing principle exists. For others, the required measurement quality is only achievable with ancillary information from accurate surface-based observing systems. In addition, since satellite measurements are often of indirect nature (the primary observed quantity being radiation), surface-based measurements play a key role for the validation of satellite-derived products.

There are still areas where exclusively surface-based systems can provide measurements of acceptable quality. However, even in those cases, satellites can be useful in spatially extending local and sparse ground measurements. In particular, the practice of assimilation makes it possible to transfer information across geophysical variables measured using different techniques: this means that satellite observations may contribute to the knowledge of geophysical variables even when not directly observed from satellite, provided that there is a strong physical relationship between these variables. Synergistic use of surface-based and space-based observations is fundamental to the WMO Integrated Global Observing System.

Note: Detailed descriptions of satellite programmes and instruments are available in the WMO online database of space-based observation capabilities: http://www.wmo.int/oscar.