Using Space-Data-Routers for the timely and targeted downloading of Land Surface Temperature data to local users

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***Abstract*— Land Surface Temperature (LST) imagery is necessary for the assessment of the urban thermal environment, an issue of increasing scientific interest due to climate change and urbanization. The problem of the exploitation of the large satellite-derived LST archive is of spatio-temporal nature. The LST input datasets are acquired from various sensors with Thermal Infrared (TIR) bands onboard geostationary (e.g. Meteosat Second Generation MSG viewing Europe and Africa) and near polar orbit (e.g. Terra and Aqua) satellites. The problem of directing and downloading the vast volumes of quarterly-hour datasets to the local users timely and accurately is not solved yet. In particular the geostationary dataset is large. The daily European LST dataset (96 images) volume is 624MB/day, that is 222.4 GB/yr. In total the decadal archive to be searched will be of the order of TerraByte. We investigate the possibility to deploy Space-Data Routers to deliver this task. This is of primary importance for the future development of a global urban observatory with hundreds of users.**

Keywords: Land Surface Temperature; Urban Heat Island; thematic quiries; big data; Space Data Routers

I. INTRODUCTION

Land surface temperature (LST) is a key parameter in the land-surface processes on all scales, combining the results of surface-atmosphere interactions and energy fluxes between the atmosphere and the ground. Urbanization introduces new surface materials (such as concrete, asphalt, tiles), and when coupled with the emission of heat, moisture and pollutants initiates one of the most dramatic human-induced change on the Earth's surface. Therefore, knowledge of LST and its temporal and spatial variations within a city environment is of prime importance to the study of urban climate and human–environment interactions and has been extensively monitored by satellite sensors (Weng, 2009; Stathopoulou and Cartalis, 2009; Hung et al., 2006; Keramitsoglou et al., 2012).

Several satellite missions have onboard spatial resolution TIR sensors and have by now acquired a considerable global archive of LST images over the last 40 years. Nevertheless, depending on the temporal and spatial requirements of a study, one has to select from broadly three categories of LST sensors. This is shown in Table 1. These missions have been providing continuous monitoring of LST distribution at the spatial resolution ranging from 3-5km for geostationary platforms to 100m from low earth orbiters. In most cases, service providers (e.g. NASA, ESA, EUMETSAT) distribute LST images as standard data products.

Multi-mission is required as complimentarity of different spatial and temporal resolutions serve the better characterization of thermal patterns. Overall, the three different spatial resolutions of 3-5km, 1km and 100 m, provide a different perspective to the study and characterization of the Urban Heat Island (UHI) phenomenon. Category B with 1km spatial and few images per day temporal resolution is an adequate compromise which gives the general picture of the hot spots and relevant patterns at a regional scale. Category C, the high spatial resolution images (~100 m), should be used for local/municipality level studies for long-term planning. Although rich in spatial detail, both Categories B and C fail to depict the diurnal variation of the phenomenon. At this point it is important to appraise the contribution of Category A (MSG-SEVIRI), which can provide an important signal for the study of the diurnal variability.

As LST is a highly dynamic parameter, research institutions who are interested in monitoring LST require access to vast quantities of space data so that they analyze and exploit them. Therefore, the efficient exploitation and dissemination of space data should not be considered as a peripheral issue, but rather as an important missing mechanism from the European Infrastructure. The Space-Data Router implements a dual role: It increases communication flexibility in Space and forms a mission-/application-oriented communication overlay for data dissemination, on Earth. The main advantage of the Space-Data Router is that it operates on top of existing network protocols and technologies, creating a DTN overlay that interconnects networks with very diverse characteristics, such as space and terrestrial. Therefore DTN provides the basic functionality for efficient space-to-earth data dissemination. In addition the router is developed on top of real space protocols allowing for the direct interoperation with current space infrastructure. Furthermore, a sophisticated application will also be

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implemented in order to support, highlight and assess system's capabilities.

Category	Thermal Sensors	Satellites	Spatial Resolution	Temporal Resolution
A	MSG-Seviri	MSG	~3-5 km	Every 15 min
B	AVHRR AATSR MODIS	NOAA-n ENVISAT Terra/Aqua	~1 km	Synergistically, a few images per day
C	ASTER TM, ETM+	Terra Landsat	~100 m	Synergistically, 1 image per week

Table 1. Different categories of thermal infrared sensors that are used in the LST scenario of SDR project

In the present note, we evaluate the possibility to use SDR to fulfill the requirements of timely and reliable LST data collection (single theme) from multiple satellite missions. For this purpose we have designed and implemented a dedicated scenario.

II. Area of Study and Data

A. Area of Study, Athens (Greece)

On the southeastern edge of the Greek mainland lies the city of Athens. Athens is the capital and largest city of Greece. The urban area is confined by high mountains interrupted by small openings, whilst it is open to the sea from the south (Saronikos Gulf). The city of Athens is characterized by a strong urban heat island effect, mainly caused by the accelerated industrialization and urbanization during recent years.

B. Data

- MSG-Seviri: The MSG LST product is computed within the area covered by the MSG disk, over 4 specific geographical regions (Europe, N. Africa, S. Africa, and S. America), every 15 minutes. For each time-slot and geographical region (Europe in the case presented here), the LST field and respective quality control data are disseminated through the Land Surface Analysis Satellite Applications Facility (LSA SAF; https://landsaf.meteo.pt/). For the present scenario the quarter-hour LST product from May 1st to September 30th 2009 were used. The daily European LST dataset (96 images) volume is 624MB/day, which is 222.4 GB/yr. In total the decadal archive to be searched will be of the order of TerraByte.
- MODIS: 50 MODIS images are used for the scenario acquired by MODIS Terra and Aqua in July 2009.
- Landsat TM: This dataset alone does not constitute a big dataset, however it is included in the scenario for two reasons: i) for completeness and to enhance the multi-mission concept and ii) to evaluate the scheduling improvements for automatic downloading.

III. Scenario: Land Surface Temperature/ Single thematic, Multi-mission

The implementation requires the development of a geo-database and its population with European LST maps acquired every 15 min from MSG geostationary satellite. The challenge is to demonstrate innovative sustainable space data exploitation methodologies for the fast assessment of the thermal environment of cities for future standard data production. It is important that the user will be able to exploit the large database fast with intelligent thematic automations, such as:

- A scheduler with a calendar interface that would enable the user to request that a specific dataset would be downloaded on specific dates in the future. For example:

"Every Monday at 08:00 UTC, starting from 1 June 2013 ending 31 June 2013, download all products:

PRODUCT=LST

Bounding Box Coordinates = …

COLLECTION = EUROPE

Acq. Time start=17:00 UTC (and later until…) Acq Time end=04:00 UTC (the next day)"

- Data-matching features that allow the user to select a specific arrangement of filters and have data sent to them directly whenever new data is added that matches the filter. For example:

"Send an email alert when the first Landsat image over Athens is available".

In this case the user might turn on and turn off the alert.

IV. Expected impact using SDR and thoughts for the future

By the LST single thematic, multi mission scenario we wish to demonstrate that SDR allows for data gathering from multiple missions for one scientific objective. In addition, same storage location for all data is of importance in that concept. This is also of interest when real time and on demand datasets are integrated in the scenario. Furthermore, as in the near future a number of relevant sensors and satellite platforms that will serve LST monitoring are in development this concept can be

enhanced. In particular, the European Space Agency (ESA) Sentinel-3 satellites are planned for launch from 2013, offering a Sea and Land Surface Temperature Radiometer (SLSTR) with a 1 km resolution in the thermal channels and a daily revisit time. The geostationary GOES-R satellite is due in 2015, with a 2 km resolution in the thermal channels from a new Advanced Baseline Imager (ABI). The National Polar-orbiting Operational Environmental Satellite System (NPOESS) is due to launch in 2016, designed to replace NASA's Aqua, Terra and Aura satellites and offering the Visible and Infrared Imagery Radiometer Suite (VIIRS) sensor for LST. Coupled with these large 'traditional' missions, in the future there is likely to be an increase in 'small satellites' (Sandau et al., 2010) that enable relatively quick and inexpensive missions, which could for example help to observe dynamic surface temperature patterns.

ACRONYMS

- **AATSR** Advanced Along Track Scanning Radiometer
- **AVHRR** Advanced Very High Resolution Radiometer
- **ESA** European Space Agency
- **EUMETSAT** European Meteorological Satellite Organisation
- **MODIS** Moderate resolution Imaging Spectroradiometer
- **MSG** Meteosat Second Generation
- **NASA** National Aeronautics and Space Administration
- **NOAA** National Oceanic and Atmospheric Administration
- **SEVIRI** Spinning Enhanced Visible and Infrared Imager
- **SLSTR** Sea and Land Surface Temperature Radiometer
- **TM** Thematic Mapper
- **ETM+** Enhanced Thematic Mapper

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